PATENT ABSTRACTS OF JAPAN

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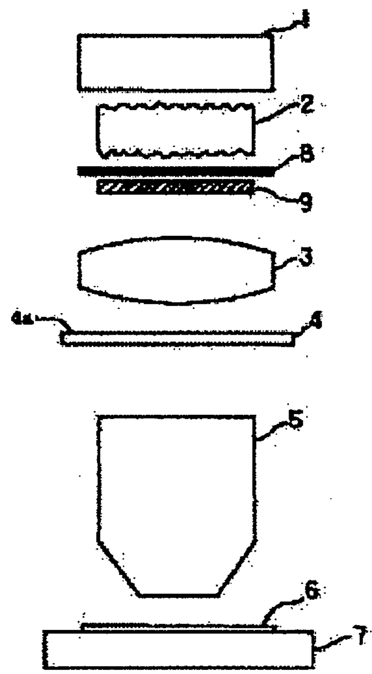
(54) METHOD OF IMAGE FORMATION, EXPOSURE SYSTEM, AND MANUFACTURE OF DEVICE

(57)Abstract:
PURPOSE: To provide an image formation and an exposure system, in which a repetitive pattern is projected using most properly polarized light to obtain a high-resolution image.
CONSTITUTION: A repetitive pattern on a reticle 4 is illuminated by a lighting system. A beam of light diffracted from the pattern is admitted to the pupil of an optical projection system to project the pattern onto a wafer 6. A deflector 9 is used to select a projection beam that is linearly polarized in a plane perpendicular substantially to the direction in which the period of the pattern is minimized.



CLAIMS

[Claim(s)]
[Claim 1]An image formation method currently carrying out image formation of the pattern of line form by a polarized light beam which polarized to a longitudinal direction of this pattern.
[Claim 2]An image formation method of Claim 1 currently illuminating said pattern by said polarized light beam.
[Claim 3]An image formation method of Claim 1 illuminating said pattern by a beam which is not polarizing and extracting said polarized light beam from a beam from said pattern.
[Claim 4]Claim 1, 2, or 3 image formation methods, wherein image formation of said pattern is substantially performed by two diffracted beams from said pattern.
[Claim 5]An image formation method of Claim 4, wherein a beam for Lighting Sub-Division is carrying out oblique incidence to said pattern.
[Claim 6]An image formation method of Claim 4, wherein said pattern is provided with a phase shifter.
[Claim 7]A device manufacturing method carrying out image formation of the pattern of line form by a polarized light beam which polarized on a machining piece at a longitudinal direction of said line, transferring said pattern on this machining piece, and manufacturing a device.
[Claim 8]A device manufacturing method of Claim 7 currently illuminating said pattern by said polarized light beam.
[Claim 9]A device manufacturing method of Claim 7 illuminating said pattern by an unpolarized light beam, and extracting said polarized light beam from a beam from said pattern.
[Claim 10]A device manufacturing method of Claim 7, wherein image formation of said pattern is substantially performed by two diffracted beams from said pattern.
[Claim 11]A device manufacturing method of Claim 10, wherein a beam for Lighting Sub-Division is carrying out oblique incidence to said pattern.
[Claim 12]A device manufacturing method of Claim 10, wherein said pattern is provided with a phase shifter.
[Claim 13]An exposure device projecting on a substrate said pattern which illuminated a pattern of line form by a polarized light beam which polarized to a longitudinal direction of said pattern by an illumination method, and was illuminated by a polarized light beam from said illumination method by a projection means, and exposing it.
[Claim 14]An exposure device of Claim 13, wherein said illumination method carries out oblique incidence of said polarized light beam to said pattern.
[Claim 15]An exposure device projecting on a substrate said pattern which illuminated a pattern of line form with an unpolarized light beam by an illumination method, and was illuminated with an unpolarized light beam from said illumination method by a polarized light beam which polarized to a longitudinal direction of said pattern by a projection means, and exposing it.
[Claim 16]An exposure device of Claim 15, wherein said illumination method carries out oblique incidence of said unpolarized light beam to said pattern.
[Claim 17]An image formation method, wherein a repeated cycle is carrying out image formation of the repeated pattern by a polarized light beam which polarized in a direction which becomes the smallest, and the direction which intersects perpendicularly substantially.

[Claim 18]An image formation method of Claim 17 currently illuminating said pattern by said polarized light beam.
[Claim 19]An image formation method of Claim 17 illuminating said pattern by a beam which is not polarizing and extracting said polarized light beam from a beam from said pattern.
[Claim 20]An image formation method of Claim 17, wherein said pattern contains a pattern which comprises a line and a space.
[Claim 21]An image formation method of Claim 17, wherein said pattern contains a dot form pattern.
[Claim 22]Claim 17, 18, 19 and 20, or 21 image formation methods, wherein image formation of said pattern is substantially performed by two diffracted beams from said pattern.
[Claim 23]An image formation method of Claim 22, wherein a beam for Lighting Sub-Division is carrying out oblique incidence to said pattern.
[Claim 24]An image formation method of Claim 22, wherein said pattern is provided with a phase shifter.
[Claim 25]A device manufacturing method a cycle of said repetition carrying out image formation of the repeated pattern on a machining piece by a polarized light beam which polarized in a direction which becomes the smallest, and the direction which intersects perpendicularly substantially, transferring said repeated pattern on this machining piece, and manufacturing a device.
[Claim 26]A device manufacturing method of Claim 25 currently illuminating said pattern by said polarized light beam.
[Claim 27]A device manufacturing method of Claim 25 illuminating said pattern by an unpolarized light beam, and extracting said polarized light beam from a beam from said pattern.
[Claim 28]A device manufacturing method of Claim 25, wherein said pattern contains a pattern which comprises a line and a space.
[Claim 29]A device manufacturing method of Claim 25, wherein said pattern contains a dot form pattern.
[Claim 30]A device manufacturing method of Claim 25, wherein image formation of said pattern is substantially performed by two diffracted beams from said pattern, 26, 27 and 28, or 29.
[Claim 31]A device manufacturing method of Claim 30, wherein an illumination beam is carrying out oblique incidence to said pattern.
[Claim 32]A device manufacturing method of Claim 30, wherein said pattern is provided with a phase shifter.
[Claim 33]A repeated pattern is illuminated by a polarized light beam which polarized in a direction to which a cycle of said repetition becomes the smallest by an illumination method, and the direction which intersects perpendicularly substantially, An exposure device projecting on a substrate said pattern illuminated by a polarized light beam from said illumination method by a projection means, and exposing it.
[Claim 34]An exposure device of Claim 33, wherein said illumination method carries out oblique incidence of said polarized light beam to said pattern.
[Claim 35]Said pattern which illuminated a repeated pattern with an unpolarized light beam by an illumination method, and was illuminated with an unpolarized light beam from said illumination method is projected on a substrate by a polarized light beam which polarized in a direction to which a repeated cycle becomes the smallest by a projection means, and the direction which intersects perpendicularly substantially, An exposure device characterized by making it expose.
[Claim 36]An exposure device of Claim 35, wherein said illumination method carries out oblique incidence of said unpolarized light beam to said pattern.
[Claim 37]An image projection method illuminating a pattern with periodicity by light flux of linear polarization corresponding to period directions of this pattern, and projecting this pattern on a predetermined side according to a projection optical system.
[Claim 38]An image projection method illuminating by light flux of linear polarization which has a plane of polarization in the direction which intersects a pattern with periodicity perpendicularly with an arrangement direction of this pattern, entering in a pupil of a

projection optical system the diffracted light produced from this pattern, and projecting this pattern on a predetermined side.

[Claim 39]It illuminates by light flux which has a plane of polarization in the direction the direction and the cycle abbreviated-cross at right angles a pattern which has periodicity via a polarization device which can change a polarization direction of linear polarization arbitrarily and can make light flux from an illumination system eject to a direction used as the shortest, An image projection method entering in a pupil of a projection optical system the diffracted light produced from this pattern, and projecting this pattern on a predetermined side.

[Claim 40]A pattern which has periodicity on a reticle side by light flux from an illumination system is illuminated, An exposure device currently illuminating by light flux of linear polarization which has a plane of polarization in the direction the direction and a cycle of this pattern abbreviated-cross this pattern at right angles to a direction used as the shortest when entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting an image of this pattern on a wafer surface.

[Claim 41]An image projection method characterized by having projected using light flux of linear polarization corresponding to period directions of this pattern when illuminating a pattern with periodicity and projecting this pattern on a predetermined side according to a projection optical system.

[Claim 42]An image projection method having projected in the direction which intersects perpendicularly with an arrangement direction of this pattern using light flux of linear polarization which has a plane of polarization when illuminating a pattern with periodicity, entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting this pattern on a predetermined side.

[Claim 43]When a pattern which has periodicity by light flux from an illumination system is illuminated, the diffracted light produced from this pattern is entered in a pupil of a projection optical system and this pattern is projected on a predetermined side, An image projection method choosing light flux which has a plane of polarization in the direction which abbreviated-intersects perpendicularly to a direction from which a cycle of this pattern serves as the shortest with a polarization device, and projecting this pattern.

[Claim 44]A pattern which has periodicity on a reticle side by light flux from an illumination system is illuminated, An exposure device having chosen and projected light flux of linear polarization which has a plane of polarization in the direction which abbreviated-intersects perpendicularly to a direction from which a cycle of this pattern serves as the shortest with a polarization device when entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting an image of this pattern on a wafer surface.

[Claim 45]A semiconductor device manufacturing method having a process of preparing the original edition with a circuit pattern, and a wafer, and Claim 37 and a process of carrying out exposure transfer of the circuit pattern of the original edition to a wafer by one method of 38, 39, 41, 42, and 43.

[Claim 46]A semiconductor device manufacturing by a manufacturing method of Claim 45.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the device manufacturing method using the exposure device and this method of using the image formation method and this method.
[0002]When especially this invention manufactures each device, such as IC, LSI, CCD, a liquid crystal panel, and a magnetic head, it relates to the device manufacturing method using the exposure device and this method using the useful image formation method and this method.
[0003]In addition, in the stepper who is a manufacturing installation of a semiconductor device, this invention illuminates an electronic circuit pattern (pattern) with small line width on reticle or a mask (the following "reticle" is called) side by suitable light flux, It is related with the exposure device using the image projection method and it which can be projected by high resolution on a wafer surface.
[0004]
[Description of the Prior Art]Since the demand to high integration of semiconductor chips, such as IC and LSI, is increasing, various improvement for improvement in the so-called resolution of the stepper (reduced-projection-exposure device) who transfers by carrying out reduction projection of the circuit pattern illuminated by ultraviolet radiation is made.
[0005]Conventionally, the method of enlarging the numerical aperture (NA) of a reduction projection lens system, the method of shortening wavelength of exposing light, etc. have been taken as a method of heightening resolution. These days apart from these methods, techniques effective in order to carry out image formation of the minute pattern (repetition minute pattern) with especially periodicity, such as a phase shift method and oblique incidence lighting, are proposed.
[0006]The image formation of a detailed pattern with periodicity is explained below.
[0007]Drawing 32 is a graph which shows the repeated pattern which comprises three detailed slits.
The pattern position X is taken along the horizontal axis of a graph, and the amplitude transmittance T is taken along the vertical axis.
Light penetrates the portion of the transmissivity 1 among a figure, and, as for the portion of the transmissivity 0, light is interrupted.
[0008]Incident light will be divided into zero-order and primary [+]-other primary high order diffracted lights if a repeated pattern with such amplitude transmittance is illuminated with a coherent light. Among these, what is contributed to formation of an image is only the diffracted light which enters into the pupil of a projection optical system, and, generally zero-order and primary [+]-the primary diffracted light enter into the pupil of a projection optical system.
[0009]Drawing 33 is an explanatory view showing the amplitude on zero-order and the primary [**] pupil of the diffracted light. 100,101,102 in a figure expresses the peak position of zero-order and primary [+]-the primary diffracted light, and IA expresses amplitude, respectively.
[0010]Drawing 34 shows the intensity distribution of the pattern image formed of zero-order and the primary [**] diffracted light. The vertical axis shows the intensity I. In the usual

image formation, if the line width of a pattern becomes very small and only the zero-order diffracted light enters into the pupil of a projection optical system, the image of a pattern will no longer be formed.

[0011]On the other hand, by manipulating in a phase shift method, at a pattern so that the phase of the diffracted light from a ****** slit may shift 180 degrees when light penetrates the above-mentioned repeated pattern, A zero-order diffracted-light ingredient is kept from appearing on the pupil of a projection optical system, and the image of a pattern is formed by the -1 order [1st / +] diffracted light.

[0012]When the repeated pattern which comprises three detailed slits is projected using a phase shift method, the amplitude distribution made on the pupil of a projection optical system is shown in drawing 35. 103,104 in a figure expresses the peak position of primary [+]-the primary diffracted-light ingredient, respectively. In this case, about the repeating cycle of a pattern, it is the same, then becomes half compared with the distance between the peak positions of the diffracted light whose distance between the peak positions 103,104 is the 1st [**] order of drawing 33. Since spatial frequency of a pattern can be seemingly made small if a phase shift method is used, the primary [**] diffracted light from a more detailed pattern enters on a pupil. Therefore, resolution improves.

[0013]Although the amplitude distribution on the pupil of drawing 33 is a thing at the time of entering light from a vertical direction to the flat surface on which the pattern was drawn, an oblique incidence method shifts the position of amplitude distribution in a transverse direction on a pupil by entering light in this flat surface from across.

[0014]Drawing 36 is an explanatory view showing the amplitude distribution on a pupil when carrying out oblique incidence of the light in a repeated pattern so that zero-order and the primary [+] diffracted light may enter on a pupil. 105,106 in a figure expresses the peak position of zero-order and the primary [+] diffracted light, respectively.

[0015]Considering forming an image by the two diffracted lights shown in drawing 36, by an oblique incidence method as well as the case of a phase shift method, the diffracted light from a more detailed pattern can reach on a pupil, and resolution improves.

[0016]

[Problem(s) to be Solved by the Invention]When the pattern of periodicity was illuminated in the effect of improvement in the resolution by the phase shift method mentioned above or oblique incidence illumination, it became clear that the polarization condition of light is concerned greatly from the result of the simulation which this invention person performed. Therefore, the problem that improvement in big resolution is not obtained even if it uses a phase shift method, oblique incidence illumination, etc. unless it changes the polarization condition of the illumination light into the optimal state to a pattern arises.

[0017]The purpose of this invention is to provide the method of carrying out device fabrication of the minute pattern using the exposure device and this method using the suitable image formation method and this method which were improved to carry out image formation.

[0018]In addition, by making the polarization condition of the light flux used for projection correspond to the period directions of a pattern, and setting it up appropriately, when this invention projects a pattern with periodicity on a predetermined side by a projection optical system, It aims at offer of the exposure device using the suitable image projection method and it for manufacture of the semiconductor device which can be projected by high contrast, maintaining high resolution. It aims at offer of the manufacturing method of the semiconductor device of the degree of high integration.

[0019]

[Means for Solving the Problem](1-1) In an image formation method which carries out image formation of the pattern of line form, the 1st gestalt of this invention carries out image formation of said pattern by a polarized light beam which polarized to a longitudinal direction of said pattern.

[0020](1-2) The 2nd gestalt of this invention carries out image formation of the pattern of line form on a machining piece, and carry out image formation of said pattern by a polarized light beam which polarized to a longitudinal direction of said pattern in a device manufacturing method which transfers said pattern on this machining piece.

[0021](1-3) In an exposure device with which the 3rd gestalt of this invention exposes a substrate by a pattern of line form, It has a means to illuminate said pattern by a polarized light beam which polarized to a longitudinal direction of said pattern, and a means to project said pattern illuminated by said illumination method on said substrate.
[0022](1-4) In an exposure device with which the 4th gestalt of this invention exposes a substrate by a pattern of line form, It has an illumination method which illuminates said pattern with an unpolarized light beam, and a projection means which projects said pattern illuminated by said illumination method on said substrate by a polarized light beam which polarized to a longitudinal direction of said pattern.
[0023](1-5) In an image formation method which carries out image formation of the repeated pattern, the 5th gestalt of this invention carries out image formation of said pattern by a polarized light beam which polarized in a direction to which a repeated cycle becomes the smallest, and the direction which intersects perpendicularly substantially.
[0024](1-6) In a device manufacturing method which the 6th gestalt of this invention carries out image formation of the repeated pattern on a machining piece, and transfers said repeated pattern on this machining piece, A repeated cycle is characterized by carrying out image formation of said pattern by a polarized light beam which polarized in a direction which becomes the smallest, and the direction which intersects perpendicularly substantially.
[0025](1-7) In an exposure device with which the 7th gestalt of this invention exposes a substrate with a repeated pattern, A repeated cycle has an illumination method which illuminates said pattern by a polarized light beam which polarized in a direction which becomes the smallest, and the direction which intersects perpendicularly substantially, and a projection means which projects said pattern illuminated by said illumination method on said substrate.
[0026](1-8) In an exposure device with which the 8th gestalt of this invention exposes a substrate with a repeated pattern, It has a means to project said pattern illuminated by an illumination method which illuminates said pattern with an unpolarized light beam, and said illumination method on said substrate by a polarized light beam which polarized in a direction to which a repeated cycle becomes the smallest, and the direction which intersects perpendicularly substantially.
[0027](1-9) In this invention, when illuminating a pattern by a polarized light beam, form a polarizing plate (film) on a substrate with which the pattern concerned was formed, provide light sources, such as laser which emits a polarized light beam, or provide a polarizing plate (film) into an optical system for this Lighting Sub-Division.
[0028]In this invention, when carrying out image formation of the pattern illuminated with an unpolarized light beam by a polarized light beam, a polarizing plate (film) is formed on substrates, such as a mask in which the pattern concerned was formed, or a polarizing plate (film) is provided into an optical system for this image formation.
[0029]It constitutes from a desirable gestalt of this invention so that a direction of a polarizing plate (film) of the above-mentioned illumination-light study system or an image formation optical system can be changed and the polarizing plate (film) concerned can be rotated around an optic axis of a system. A polarized light beam which polarized towards desired by this composition can be formed.
[0030]1/2 wavelength plate (film) is formed into the above-mentioned illumination-light study system or an image formation optical system, and it constitutes from an another desirable gestalt of this invention so that a direction of an optical axis of the 1/2 wavelength plate (film) concerned can be changed and the 1/2 wavelength plate (film) concerned can be rotated around an optic axis of a system. A polarized light beam which polarized towards desired by this composition can be formed.
[0031]A pattern which is different on a substrate is formed in this invention, When longitudinal directions of these patterns differ mutually or directions (the minimum period directions) with the smallest cycle of a repetition of these patterns differ mutually, Image formation of each pattern is carried out by a polarized light beam which corresponded without a direction which intersects perpendicularly with a longitudinal direction or/and the minimum period directions of each pattern.
[0032]When performing such image formation simultaneously, where a polarizing plate (film)

corresponding to them is provided for every pattern, supply an unpolarized light beam, or, Where 1/2 wavelength plate (film) for making other patterns other than one pattern produce polarization corresponding to it or them is formed, a polarized light beam corresponding to said one pattern is supplied. This polarizing plate (film) and 1/2 wavelength plate (film) are good to provide at least in one side by the side of light incidence of a pattern, or irradiation appearance.
[0033]When performing such image formation one by one, an illumination-light study system or an image formation optical system is constituted like the aforementioned desirable gestalt, and a polarized light beam corresponding to each pattern is generated.
[0034]With a desirable gestalt of this invention, said pattern is illuminated by illumination beam from an oblique position, or a phase shifter is supplied to said pattern, and image formation is substantially performed by two diffracted beams from said pattern.
[0035](1-10) It is characterized by an image projection method of this invention illuminating a pattern with periodicity (1-10-I) by light flux of linear polarization corresponding to period directions of this pattern, and projecting this pattern on a predetermined side according to a projection optical system.
[0036](1-10-**) It illuminates by light flux of linear polarization which has a plane of polarization in the direction which intersects a pattern with periodicity perpendicularly with an arrangement direction of this pattern, the diffracted light produced from this pattern is entered in a pupil of a projection optical system, and it is characterized by projecting this pattern on a predetermined side.
[0037](1-10-**) It illuminates by light flux which has a plane of polarization in the direction the direction and the cycle abbreviated-cross at right angles a pattern which has periodicity via a polarization device which can change a polarization direction of linear polarization arbitrarily and can make light flux from an illumination system eject to a direction used as the shortest, The diffracted light produced from this pattern is entered in a pupil of a projection optical system, and it is characterized by projecting this pattern on a predetermined side.
[0038](1-10-**) When illuminating a pattern with periodicity and projecting this pattern on a predetermined side according to a projection optical system, it is characterized by having projected using light flux of linear polarization corresponding to period directions of this pattern.
[0039](1-10-**) When illuminating a pattern with periodicity, entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting this pattern on a predetermined side, it is characterized by having projected in the direction which intersects perpendicularly with an arrangement direction of this pattern using light flux of linear polarization which has a plane of polarization.
[0040](1-10-**) A pattern which has periodicity by light flux from an illumination system is illuminated, When entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting this pattern on a predetermined side, it is characterized by choosing light flux which has a plane of polarization in the direction which abbreviated-intersects perpendicularly to a direction from which a cycle of this pattern serves as the shortest with a polarization device, and projecting this pattern.
[0041](1-11) A pattern which has periodicity on a reticle side by light flux from an illumination system (1-11-I) as an exposure device of this invention is illuminated, When entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting an image of this pattern on a wafer surface, it is characterized by illuminating by light flux of linear polarization which has a plane of polarization in the direction the direction and a cycle of this pattern abbreviated-cross this pattern at right angles to a direction used as the shortest.
[0042](1-11-**) A pattern which has periodicity on a reticle side by light flux from an illumination system is illuminated, When entering in a pupil of a projection optical system the diffracted light produced from this pattern and projecting an image of this pattern on a wafer surface, it is characterized by having chosen and projected light flux of linear polarization which has a plane of polarization in the direction which abbreviated-intersects perpendicularly to a direction from which a cycle of this pattern serves as the shortest with a polarization device.

[0043]
[Example]Before describing each working example of this invention first, a theory higher-precision than what is called scalar diffraction theory used for the simulation of a general imaging characteristic and the above-mentioned scalar diffraction theory which this invention person used for the simulation is explained.
[0044]In scalar diffraction theory, if an objective pattern is illuminated, the Fourier transform image of that pattern will be formed on the entrance pupil of a projection optical system, the Fourier transform of this Fourier transform image will be again carried out within the limits of the numerical aperture (NA) of a projection optical system, and the pattern image of the amplitude distribution on the image surface will be formed. Amplitude A (x, y) in the point (x, y) on the image surface if this is expressed by a formula [0045]
[Equation 1]

$$A(x, y) = \iint F\left(U(x_1, y_1)\right) \exp\left\{ik(\alpha x + \beta y)\right\} d\alpha d\beta \quad \text{と書ける。}$$

The inside F of a formula (U (x_1, y_1)) is the Fourier transform of the amplitude transmittance U of a pattern (x_1, y_1), and is carrying out the Fourier transform of this Fourier transform again within the limits of the pupil surface decided by the numerical aperture of a projection optical system. However, in the inside of a formula (alpha, beta), it is the coordinates on a pupil surface and F (U (x_1, y_1)) has become a function of (alpha, beta).
[0046]although it is a formula when this formula has the coherent illumination light — the illumination light -- a portion -- although some treatment becomes complicated, it is also fundamentally the same as when coherent.
[0047]In the simulation using the formula described above, when the numerical aperture of a projection optical system was small, the right result was obtained, but it became clear that the problem of flume shoes that the numerical aperture becomes large arises by examination which this invention person performed.
[0048]The first problem of an upper type is that the polarization condition of incident light is not taken into consideration. This is explained using figures. The example of the repeated pattern which comprises the three above-mentioned slits is used for explanation.
[0049]Drawing 26 is drawing the amplitude distribution on the pupil shown by drawing 33 on the reference surface of a sphere 111 on the basis of the Gauss image point 110 of a projection optical system. The amplitude in the point 110 on the image surface 112 will be decided by integration of the amplitude on the reference surface of a sphere 111 if the wavefront aberration of a projection optical system is disregarded, The amplitude in the point that only the distance x shifted from the point 110 on the image surface 112 is calculated by considering a certain phase contrast decided from the coordinates on the distance x and the reference surface of a sphere 111, and integrating with the amplitude on the reference surface of a sphere 111.
[0050]In order that the point may simplify the talk from here, an argument will be restricted to calculation of the amplitude in the point 110. The axis of coordinates is defined here.
[0051]As shown in drawing 26, use an optic axis as the z-axis, and let a x axis and the axis of a direction vertical to space be the y-axes for an axis vertical to the z-axis within space. In the view by the scalar diffraction theory expressed above, the amplitude in the point 110 is calculated in the form where the amplitude on the reference surface of a sphere 111 was added as it was.
[0052]Light has polarization, and even if it compares and is completely coherent lights, if the polarization directions differ, it will not interfere thoroughly, and if it lies at right angles, for example, interference will not take place at all.
[0053]If a slit is illuminated with light from a direction parallel to the z-axis, on the reference surface of a sphere 111, the amplitude distribution of drawing 26 will be formed, noting that the longitudinal direction of the slit which constitutes a repeated pattern is parallel to the y-axis and a repeated pattern has a cycle in x shaft orientations. The illumination light is the linear polarized light which polarized to y shaft orientations (direction parallel to a slit), and if change of a polarization direction can be disregarded within a projection optical system, the polarization direction in each point of the above-mentioned amplitude distribution as well as

the illumination light turns into y shaft orientations in all the positions.
[0054]Supposing the amplitude distribution on the reference surface of a sphere 111 is formed only with the light which polarized to y shaft orientations among the lights diffracted to the slit, all the polarization directions of the light which reaches on the image surface 112 will also become the same. Also in this case, the amplitude in the point 110 can be found by integrating with the amplitude on the reference surface of a sphere 111 as it is.
[0055]When the illumination light is the linear polarized light which polarized to x shaft orientations (direction which intersects perpendicularly with a slit) on the other hand, as it is shown in drawing 27, When the typical beams of light 120-124 turned to the point 110 from the reference surface of a sphere 111 are considered, the polarization direction of the conditions that a polarization direction and the direction of movement of light intersect perpendicularly to the beams of light 120-124 becomes like the arrow in [125-129] a figure, respectively. The polarization in this case has x and a z car polarization component, and it is necessary to consider the amplitude in the point 110 for every polarization component. The luminous intensity in the point 110 serves as the sum total of the intensity obtained from the amplitude by each polarization component.
[0056]Next, the result of having performed the simulation with the application of this view is explained. In the image formation using zero-order and primary [+]-the primary diffracted-light ingredient first explained by drawing 33. The final intensity distribution acquired by of which direction of x shaft orientations and y shaft orientations a polarization component is used among the lights diffracted from a slit as opposed to two polarization directions of the illumination light becomes like drawing 28 and drawing 29, respectively.
[0057]Drawing 28 is when the polarization direction of the illumination light is parallel to a slit, and an image is formed only by the polarization component of y shaft orientations. On the other hand, drawing 29 is when the polarization direction of the illumination light is vertical to a slit, and an image is formed as the sum total of x polarization component and z polarization component.
[0058]What evaluated the image formation using two of zero-order and primary [+]-the primary three diffracted lights by the same simulation like a phase shift method or oblique incidence illumination is shown below.
[0059]If only the result of the intensity distribution on the image surface is shown, it will become the intensity distribution as which a polarization direction indicates it in drawing 31 at the intensity distribution as which the polarization direction of the illumination light indicates in drawing 30 in the case of y shaft orientations (parallel to a slit) in the case of x shaft orientations (vertical to a slit).
[0060]Here, when a polarization direction is vertical to a slit, it is influence of the polarization component of the direction of z, and compared with the case where a polarization direction is parallel to a slit, the contrast of an image is quite bad. Since the illumination light is in the state where it does not polarize, in the ordinary exposure, intensity distribution becomes drawing 30 and the thing which averaged the intensity distribution of drawing 31, but compared with the intensity distribution of drawing 31, contrast deteriorates even in such a case.
[0061]Thus, it became clear that the polarization direction of the illumination light has big influence on an imaging characteristic from the result of the simulation with high accuracy which this invention person performed.
[0062]In order to raise resolution especially, when a phase shift method or oblique incidence illumination is applied, the resolution beyond expectation is obtained by controlling the polarization direction of the illumination light appropriately to a pattern with the periodicity to project.
[0063]The above is a result of the simulation about the imaging characteristic which this invention performed.
[0064]Next, each working example of this invention is described.
[0065]Drawing 1 is an important section schematic diagram of working example 1 when the image projection method of this invention is applied to the stepper for device fabrication, such as a semiconductor device, CCD, a liquid crystal panel, and a magnetic head (step & repeat-die projection aligner).

[0066]One is light sources, such as an ultrahigh pressure mercury lamp, among a figure. The light which came out of the light source 1 illuminates the pattern (circuit pattern) 4a on the 4th page of reticle with the illumination lens 3 via the aperture 8 and the polarization device 9 with which luminous energy distribution was equalized by the optical integrator 2. The light diffracted by the pattern 4a of the reticle 4 enters into the projection lens 5, and forms the image of the pattern 4a on the semiconductor wafer 6 which appeared on the stage 7 via the projection lens 5.
[0067]The light ejected from the optical integrator 2 here, All those light flux does not reach the illumination lens 3, but only the portion which was suitable for Lighting Sub-Division by the aperture 8 of the place which is the aperture diaphragm approached and put on the optical integrator 2 is chosen, When a selected light penetrates the polarization device 9, the polarization condition is changed into linear polarization from the state of a circle, elliptical polarization, or unpolarized light. The polarization device 9 can change the polarization direction of linear polarization according to conditions, such as the direction of a repetition of the pattern 4a.
[0068]The circuit pattern 4a with small line width for performing transfer of a up to [the barrel body wafer 6] is drawn on the reticle 4.
The illumination light which enters into the reticle 4 via the illumination lens 3 penetrates the reticle 4 according to the above-mentioned circuit pattern 4a.
Photosensitive materials, such as resist, are applied on the semiconductor wafer 6, and it is possible to transfer the image of the circuit pattern 4a there.
[0069]On the semiconductor wafer 6, the projection lens 5 contracted to predetermined magnification (generally 1/5 or 1/10), and has projected the image of the circuit pattern 4a on the reticle 4. In that case, the reticle 4 and the semiconductor wafer 6 are adjusted to position relations by driving the stage 7. An end of the exposure to a certain shot on the semiconductor wafer 6 will repeat that specified quantity movement is horizontally carried out by the stage 7, and the semiconductor wafer 6 exposes the other shots on the semiconductor wafer 6 by it there.
[0070]In this example, the repeated pattern which arranged in 5 x directions the slit prolonged in the y direction shown in drawing 2 and which has periodicity in a x direction is used as the circuit pattern 4a on the reticle 4. In the circumference of these openings 10-4, by an opening, the inside 10-14 of a figure comprises a shade part, and light penetrates only this portion. The dashed dotted line 15 is a base line drawn to the repeating direction (x direction) of the slit shape openings 10-14, and is used by next explanation.
[0071]Here, the contrast of an image is raised when a chief ray illuminates the reticle 4 by the light flux leaning to the reticle 4 from the perpendicular direction.
[0072]Drawing 3 is the sectional view which met the dashed dotted line 15 of the pattern 4a of drawing 2. It is made for the chief ray of light flux to become slanting in ZX flat surface which the pattern 4a has repeated as a direction which leans the light flux 20 and 21 by oblique incidence illumination as shown in drawing 3. As shown in drawing 4, the opening of the aperture 8 consists of this examples, in order to fulfill this condition. The cycle of the repetition of the pattern 4a has turned to the x axis in the direction which becomes the smallest.
[0073]In drawing 4, the shadow area 22 is a shielding region currently shaded so that light may not pass. The two circular openings 23 and 24 are light transmission areas, and the light from these fields 23 and 24 contributes them to the image formation of the pattern 4a. 25 are the base line drawn so that it might pass along the center of the circular openings 23 and 24 among a figure.
[0074]Next, the illumination light selected by the aperture 8 of drawing 1 enters into the polarization device 9. As the polarization device 9 is shown in drawing 5, only the polarization light of the y direction shown by the figure Nakaya seal 26 among the polarization components of the light which enters from the upper surface of the polarization device 9 is made to penetrate, and the polarization light of other directions has structure which is interrupted. The dashed dotted line 27 in a figure is a base line drawn in the direction which intersects perpendicularly with the above-mentioned arrow 26. Arrangement in the level surface of the reticle 4 of drawing 1, the aperture 8, and the polarization device 9 is set up

so that drawing 2 and the base lines 15, 25, and 27 shown in 4 and 5, respectively may become parallel mutually.
[0075]The polarization direction of the oblique incidence illumination light is made to become a y direction parallel to the slit direction of the pattern 4a by the above composition, That is, as the x direction used as the minimum and the cycle of a repetition of the pattern 4a cross at right angles, when it burns with the image formation of the pattern 4a, as drawing 30 explained, it is high resolution and the high image of contrast has been acquired on the semiconductor wafer 6. The case of the repeated pattern on a dot also has the same effect as a pattern on the reticle 4.
[0076]Next, in this example, the case where each has length and two patterns which have periodicity in the 2-way of (horizontal y, x) as the pattern 4a on the reticle 4 shows not only the single pattern that has periodicity in the one direction like drawing 2 but drawing 6 is explained.
[0077]In this case, the repeated pattern of the portion surrounded with the dashed line 30 of drawing 6 can perform projection transfer good by using an above-mentioned method. However, since the polarization direction of the illumination light becomes in the direction which intersects perpendicularly with a slit about the repeated pattern of the portion surrounded with the dashed line 31, the same effect is not acquired.
[0078]So, in this example, the reticle of drawing 6 is divided into the reticle of two sheets shown in drawing 7 and drawing 8, and is exposed independently. Namely, burn by the linear polarized light which polarized to the y direction, and as mentioned above about the pattern of drawing 7 about the pattern of drawing 8. So that the illumination light may carry out oblique incidence to reticle in the flat surface which a pattern repeats and the polarization direction of the illumination light may turn into a direction parallel to the longitudinal direction of a slit, That is, after fixing since the aperture 8 and the polarization device 9 are rotated 90 degrees centering on an optic axis in the level surface with an unillustrated drive so that it may become the linear polarized light which polarized to the x direction, it is burning. This method can be similarly applied, when the pattern of a slit becomes not only in the 2-way of length and width but in other directions.
[0079]As shown in drawing 6, when one reticle has two kinds of repeated patterns, each pattern is illuminated one by one using the masking blade provided in reticle and a conjugate place, and each pattern is illuminated by polarization light with a described method.
[0080]This example explained noting that the pattern on reticle was formed in the five line & space, but it is applicable to line & space patterns other than five similarly. The ratio of the width of a line & space is not restricted to 1 to 1, and even when the cycle of a pattern becomes [and also] to some extent irregular, this invention can be applied similarly.
[0081]In this example, the polarization device 9 may be arranged between the illumination lens 3 and the reticles 4, between the reticle 4 and the projection lenses 5, or inside the projection lens 5 (on a pupil surface).
[0082]When the polarization device 9 has been arranged between the reticle 4 and the projection lens 5, With the polarization device 9, the polarization light which polarized in the specific direction among the diffracted lights diffracted by the pattern 4a according to the pattern shape on the reticle 4 is chosen, and only this selected polarization beam comes to enter into the projection lens 5. And the image of the pattern 4a is projected on the wafer 6 by this polarization beam.
[0083]Next, working example 2 of this invention is described. the equipment configuration of working example 2 -- working example 1 of drawing 1 -- abbreviated -- it is the same. The point that working example 2 differs from working example 1 is having applied the phase shift method to the pattern on the reticle 4.
[0084]Drawing 9 is an explanatory view of the pattern 4a on the reticle 4 of this example. As shown in the figure, the pattern 4a of the point which comprises the slit shape openings 40-44 prolonged in five y directions is the same as that of working example 1 of drawing 1, but. The pattern of drawing 9 has the feature in the point that the phase shifter to which the phase of the light penetrated to the shadow areas 40, 42, and 44 is changed 180 degrees to the light which penetrates the portions 41 and 43 is provided.
[0085]In this example, what can penetrate only the light from the opening of the circular

portion 46 of the center surrounded by the shade part of the shadow area 45 as shown in drawing 10 is used as shape of the aperture 8.
[0086]He combines the same polarization device 9 as working example 1 using the pattern 4a and the aperture 8, and is trying for the polarization direction of the illumination light to turn into a direction (y direction) parallel to the longitudinal direction of a slit to the pattern 4a in drawing 9 in this example. The good pattern is burned using the phase shift method by this.
[0087]Even when it is two or more sorts which the repetition has produced in the direction which the number of the patterns 4a on the reticle 4 is not one like drawing 9, and is different like drawing 6, It can be coped with by using two or more reticles for every pattern of the same direction like working example 1, or burning by dividing using a masking blade.
[0088]Next, working example 3 of this invention is described. the equipment configuration of working example 3 — working example 1 of drawing 1 — abbreviated — it is the same.
[0089]In this example, what is shown in drawing 11 is used as the pattern 4a on the reticle 4. Among drawing 11, four are reticle and determine that a coordinate system becomes vertical to the reticle 4 about the reticle 4, parallel, and the z-axis in xy side as well as said each working example. 210-214 are the slit shape openings of the pattern A among drawing 11, and the openings 210-214 constitute the repeated pattern in the x direction shown by the arrow 215.
[0090]220-224 are the slit shape openings of the pattern B similarly, and the openings 220-224 constitute the repeated pattern in the y direction shown by the arrow 225. The phase shift method is applied to each of the pattern A and the pattern B. The details of the patterns A and B which applied the phase shift method are explained using drawing 12.
[0091]Drawing 12 draws the section which met the arrow 215 about the pattern A shown in drawing 11. 230 are a transparent glass substrate among drawing 12, and the slash part 231 is a shade part which comprises chromium. Period pattern A is formed of the shade part 231 and the openings 210-214. A phase shift method raises the resolution of an image formation system by changing the phase of the light which penetrates an opening by a unit of 180 degrees between adjacent openings.
The phase shifter to which the phase of the light in which 32-34 in drawing 12 penetrate that is changed 180 degrees is shown.

[0092]The sectional view which met the arrow 225 also about period pattern B becomes being the same as that of drawing 12. Since what is necessary is just to perform Lighting Sub-Division from a direction (the direction of z) vertical to the reticle 4, as shown in drawing 13, as the aperture 8, the surrounding slash part 240 uses a shade part and the thing from which 241 of the center is an opening for the image formation of the pattern which applied the phase shift method.
[0093]In this example, what is shown in drawing 14 as the polarization device 9 is applied. Among the lights which enter there, among drawing 14, the polarization device 9 is constituted so that only the polarization light of the y direction shown with the double arrow 50 may be made to penetrate. That is, a stepper's illumination light in this example turns into linear polarized light which has a plane of polarization in y shaft orientations, after penetrating the polarization device 9.
[0094]When the pattern 4a on the reticle 4 is illuminated with the above composition, the relation of the polarization direction of the patterns A and B and the illumination light comes to be shown in drawing 15 and drawing 16. That is, to the pattern A, as shown in drawing 15, the polarization direction 60 becomes the longitudinal direction of a slit and parallel which constitute a pattern, and this fulfills the conditions whose resolution improves as above-mentioned.
[0095]As shown in drawing 16 to the pattern B on the other hand, the polarization direction 61 is vertical to the longitudinal direction of the slit which constitutes a pattern, and, the way things stand, an improvement of the resolution like the pattern A cannot be performed to the pattern B.
[0096]Then, the plane of polarization of the linearly polarized light flux which enters into the pattern B is rotated 90 degrees, and it enables it to illuminate the pattern B in this example by the linearly polarized light flux of a direction parallel to the slit of the pattern B.

[0097]Although drawing 17 is a top view of the reticle 4 showing the pattern A and the pattern B like drawing 11, the point which is polarizing the polarized light converter 70 made to rotate the plane of polarization of the linearly polarized light flux into which the reticle 4 of drawing 17 enters just before the pattern B 90 degrees is the feature. As the polarized light converter 70, 1/2 wavelength plate is applicable, for example. The situation of the polarization plane rotation at the time of applying 1/2 wavelength plate is explained using drawing 24.
[0098]If the direction of the optical axis 82 of a polarized light converter (here 1/2 wavelength plate) is arranged to the linearly polarized light flux which progressed in the direction of the arrow 80 and polarized in the direction of the double arrow 81 (y direction) among drawing 18 so that a x axis and the angle of 45 degrees may be made, The light flux after penetrating the polarized light converter 70 progresses in the direction of the arrow 83, and is changed into the linearly polarized light flux which polarized to x shaft orientations as the double arrow 84 showed.
[0099]By arranging the polarized light converter 70 just before the pattern B comes to show the relation of the polarization direction of the pattern B and illumination luminous flux to drawing 19. That is, since the direction of the polarization which the double arrow 90 shows becomes a relation parallel to the slit which constitutes the pattern B, improvement in the same resolution as the pattern A can be realized also to the pattern B.
[0100]If the optical material which had optical rotation as the polarized light converter 70 is applied, it will become possible to control the size of the rotatory polarization of linearly polarized light flux by thickness of the polarized light converter 70, In that case, since the rotatory polarization angle of linearly polarized light flux can set it as a value like [other than 90 degrees] by control of thickness, improvement in resolution is attained to the repeated pattern of various directions.
[0101]This example explained noting that the phase shift method was applied to the pattern which illuminates, but it cannot be overemphasized that it can apply even when oblique incidence illumination is used.
[0102]There is a modification which forms the polarization device 9 on the surface of the reticle 1 or a rear face in each above working example.
[0103]Drawing 20 is an important section schematic diagram of working example 4 when the image projection method of this invention is applied to the stepper for manufacture of a semiconductor device. The same code number is given to the same element as the element shown by drawing 1 among the figure.
[0104]In drawing 20, since it is the same as that of the thing of drawing 1, the light source 1, the optical integrator 2, the illumination lens 3, the reticle 4, the projection lens 5, the semiconductor wafer 6, and stage 7 grade are omitted here, respectively.
[0105]The point that working example 4 differs from working example 1-3 is a position in the optical path in which the polarization device is installed. In this example, the polarization device 59 is arranged just before the reticle 54 (between the illumination lens 3 and the reticles 54), and it has composition which controls the polarization condition of the light which enters into the reticle 54 just before the reticle 54.
[0106]Here, the pattern 54a on the reticle 54 of this example consists of a repeated pattern which comprises the slits 60-64 prolonged in a lengthwise direction (y direction) as shown in drawing 21, and a repeated pattern which comprises the slits 65-69 prolonged in a transverse direction (x direction). Thus, what is necessary is just to carry out the opening of the aperture 8 like drawing 22, in order to raise resolution with oblique incidence Lighting Sub-Division to the pattern of the direction in every direction.
[0107]The circular opening parts 71-74 provided in four corners are light transmission sections by the shade part, and the slash part 70 in drawing 22 carries out oblique incidence of the light from these openings 71-74 to the reticle 4.
[0108]In this example, to such oblique incidence illumination, the polarization device 59 is arranged so that the polarization direction of the light which enters into the pattern 54a may always become parallel to the longitudinal direction of a slit.
[0109]59a and 59b in drawing 21 are a polarizing member which makes only the linear polarized light which polarized in one certain direction among the lights which entered

penetrate, and the polarizing member 59a is installed so that only the polarization light which polarized among the lights which entered without the direction (y direction) parallel to the longitudinal direction of the slits 60-64 may be penetrated.
[0110]On the other hand, the polarizing member 59b is arranged so that only the polarization light which polarized in the direction (x direction) parallel to the longitudinal direction of the slits 65-69 may be made to penetrate. What determined the direction of a polarization axis according to the corresponding pattern, and stuck the filmy polarizing plate on the reticle 54 as the polarization device 59 is applicable.
[0111]Although this example explained the thing with the slit prolonged in a 2-way in every direction as the pattern 54a on the reticle 54, it is applicable similarly to a pattern with the slit prolonged in the other direction.
[0112]In this example, the polarization device 9 may be arranged immediately after the reticle 54 (between the reticle 54 and the projection lenses 55).
[0113]Even if the polarization device 9 has a slit prolonged in the various directions on the reticle 54, it enables it to choose the polarization light which polarized to the longitudinal direction of the slit independently for every slit of each direction among the lights diffracted from the slit, and at this time, it is made to carry out image formation by this polarization light.
[0114]Next, working example 5 of this example is described. the equipment configuration of working example 5 -- working example 1 of drawing 1 -- abbreviated -- it is the same. Working example's 5 differing from working example 4 is having applied the phase shift method to the pattern on the reticle 4.
[0115]Drawing 23 is an explanatory view of the pattern 54a on the 54th page of the reticle of this example. At the point which comprises the slits 80-84 prolonged in a lengthwise direction (y direction), and the slits 85-89 prolonged in a transverse direction (x direction), although the pattern on the reticle 54 shown in the figure is the same as the pattern of drawing 21, In this example, it differs in that the phase shift member is provided to the extent that the phase of the light penetrated into the portions 80, 82, 84, 85, 87, and 89 to which the slash is given is changed 180 degrees to the light which penetrates the portions 81, 83, 86, and 88 to the slit in a figure.
[0116]59a and 59b are entering in a slit only the polarization light which polarized to the longitudinal direction of the slit among the light, when the light or unpolarized light light which is a polarizing member and polarized to the circle or the ellipse at the reticle 54 enters. As the aperture 8, what was shown in drawing 13 like the case of working example 2 is used.
[0117]At this example, by the above composition, even when improvement in resolution is aimed at with a phase shift method and the pattern of the direction in every direction is on the reticle 54, image formation is carried out on the semiconductor wafer 6 by polarization light suitable for each pattern.
[0118]Although it has a slit prolonged in a 2-way in every direction as a pattern on the reticle 54 and being explained here, it is applicable similarly to a pattern with the slit prolonged in the other direction.
[0119]Although shown here taking the case of the case where the pattern on reticle is formed in the five line & space, it is applicable to line & space patterns other than five similarly. The ratio of the width of a line & space is not restricted to 1 to 1, and even when the periodicity of a pattern becomes [and also] to some extent irregular, it can be applied similarly.
[0120]It is good also considering the laser which emits linear polarized light not using a lamp and a polarization device as a light source for exposure. When using the time of using a polarization device, and laser, 1/2 wavelength plate is put into an optical path, this is rotated, and it may be made to make desired polarization light.
[0121]Next, working example of the device manufacturing method using the exposure device which explained [above-mentioned] is described. Drawing 24 shows the flow of manufacture of semiconductor devices (semiconductor chips, such as IC and LSI, or a liquid crystal panel, CCD, etc.).
[0122]The circuit design of a semiconductor device is performed at Step 1 (circuit design). The mask in which the designed circuit pattern was formed is manufactured at Step 2 (mask

manufacture).
[0123]On the other hand, at Step 3 (wafer manufacture), a wafer is manufactured using materials, such as silicon. Step 4 (wafer process) is called a previous process, and forms the circuit of working example on a wafer with a lithography technology using the mask and wafer which prepared [above-mentioned].
[0124]The following step 5 (assembly) is called a post process, is a process semiconductor-chip-ized using the wafer created by Step 4, and includes processes, such as an assembly process (dicing, bonding) and a packaging process (chip enclosure). At Step 6 (inspection), the operation confirming test of the semiconductor device produced at Step 5, an endurance test, etc. are inspected. A semiconductor device is completed through such a process and this is shipped (Step 7).
[0125]Drawing 25 shows the detailed flow of the above-mentioned wafer process.
[0126]The surface of a wafer is oxidized at Step 11 (oxidation). An insulator layer is formed in a wafer surface at Step 12 (CVD). At Step 13 (electrode formation), an electrode is formed by vacuum evaporation on a wafer. Ion is driven into a wafer at Step 14 (ion implantation). A sensitizing agent is applied to a wafer at Step 15 (resist process). At Step 16 (exposure), with the exposure device which explained [above-mentioned], the circuit pattern of a mask is baked on a wafer and exposed. The exposed wafer is developed at Step 17 (development). At Step 18 (etching), portions other than the developed resist image are shaved off. The resist which etching could be managed with Step 19 (resist removing), and became unnecessary is removed. By carrying out by repeating these steps, a circuit pattern is formed on a wafer multiplex.
[0127]If the manufacturing method of this example is used, the semiconductor device which is the degree of high integration for which manufacture was difficult can be manufactured conventionally.
[0128]
[Effect of the Invention]In this invention, each element is set up as mentioned above. Therefore, the method of manufacturing a device using the exposure device and this method using the suitable image formation method and this method which were improved to carry out image formation of the minute pattern can be attained.

[0129]In addition, in this invention, when projecting the pattern which has periodicity as mentioned above on a predetermined side by a projection optical system, the polarization condition of the light flux used for projection is made to correspond to the period directions of a pattern, and is set up appropriately.
Therefore, the suitable image projection method for manufacture of the semiconductor device which can be projected by high contrast and an exposure device, and also a manufacturing method can be attained, maintaining high resolution.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The important section schematic diagram of working example 1 when the image projection method of this invention is applied to a stepper
[Drawing 2]The explanatory view of the reticle of drawing 1
[Drawing 3]The explanatory view showing the situation of the illumination light to the reticle of drawing 1
[Drawing 4]The explanatory view of the aperture of drawing 1
[Drawing 5]The explanatory view of the polarization device of drawing 1
[Drawing 6]The explanatory view of other working example of the reticle of drawing 1
[Drawing 7]Some explanatory views of drawing 6
[Drawing 8]Some explanatory views of drawing 6
[Drawing 9]The explanatory view of the reticle concerning working example 2 of this invention
[Drawing 10]The explanatory view of the aperture concerning working example 2 of this invention
[Drawing 11]The figure showing the pattern on reticle
[Drawing 12]The figure showing the section of the pattern on the reticle of drawing 11
[Drawing 13]The figure showing the aperture concerning working example 3 of this invention
[Drawing 14]The figure showing the polarization device concerning working example 3 of this invention
[Drawing 15]The figure showing the pattern of drawing 11, and the relation of polarization of the illumination light
[Drawing 16]The figure showing the pattern of drawing 11, and the relation of polarization of the illumination light
[Drawing 17]The figure showing the pattern on REKUCHIRU concerning working example 3 of this invention
[Drawing 18]The figure showing work of the polarized light converter concerning working example 3 of this invention
[Drawing 19]The figure showing the pattern of drawing 17, and the relation of polarization of the illumination light
[Drawing 20]The important section schematic diagram of working example 4 when the image projection method of this invention is applied to a stepper
[Drawing 21]Some explanatory views of drawing 11
[Drawing 22]Some explanatory views of drawing 11
[Drawing 23]The explanatory view of the reticle concerning working example 5 of this invention
[Drawing 24]The flow chart figure of the manufacturing method of the semiconductor device concerning this invention
[Drawing 25]The flow chart figure of the wafer process in the manufacturing method of the semiconductor device concerning this invention
[Drawing 26]The explanatory view showing the amplitude distribution on a pupil
[Drawing 27]The explanatory view for explaining the difference in the polarization direction by the angle of a beam of light

[Drawing 28]The explanatory view showing the intensity distribution on the image surface when the light which polarized in the direction parallel to a slit is used
[Drawing 29]The explanatory view showing the intensity distribution on the image surface when the light which polarized in the direction vertical to a slit is used
[Drawing 30]A phase shift method when the light which polarized in the direction parallel to a slit is used, the explanatory view of the intensity distribution on the image surface by oblique incidence Lighting Sub-Division
[Drawing 31]A phase shift method when the light which polarized in the direction vertical to a slit is used, the explanatory view of the intensity distribution on the image surface by oblique incidence Lighting Sub-Division
[Drawing 32]The explanatory view showing the amplitude transmittance of a repeated pattern

[Drawing 33]The explanatory view showing the amplitude distribution on a pupil
[Drawing 34]The explanatory view showing the intensity distribution on the image surface
[Drawing 35]The explanatory view showing the amplitude distribution on the pupil at the time of using a phase shift method
[Drawing 36]The explanatory view showing the amplitude distribution on the pupil at the time of using oblique incidence Lighting Sub-Division
[Description of Notations]
1 Light source
2 Optical integrator
3 Illumination lens
4 Reticle
5 Projection lens
6 Semiconductor wafer
7 Stage
8 Aperture
9 Polarization device

[Translation done.]

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[Amendment 1]
[Document to be Amended]Description
[Item(s) to be Amended]Title of invention
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[Title of the Invention]A projection exposure method, a device, and an exposure device
[Amendment 2]
[Document to be Amended]Description
[Item(s) to be Amended]Claims
[Method of Amendment]Change
[Proposed Amendment]
[Claim(s)]
[Claim 1]Illuminate an illuminated field of specified shape by illumination light, and a pattern image on a mask in an illuminated field of said specified shape is exposed to a substrate on a stage via a projection optical system, In a projection exposure method which exposes a pattern image of an area larger than an illuminated field of said specified shape on said mask

on said substrate by scanning said mask and said substrate synchronously relatively to an illuminated field of said specified shape,
A reference mark member which forms two or more marks for Measurement Division towards said relative scan on said mask and by which two or more reference marks were formed in a mark for Measurement Division of this plurality and an almost conjugate position is arranged on said stage,
Said mask and said substrate are moved synchronizing with the direction of said relative scan, and the amount of position gaps of one mark for Measurement Division in two or more marks for Measurement Division on said mask and a corresponding reference mark on said stage is measured one by one,
A projection exposure method characterized by asking for correspondence relation between a coordinate system on said mask, and a coordinate system on said stage from each amount of position gaps of a mark for Measurement Division of said plurality, and two or more of said reference marks.
[Claim 2]Illuminate an illuminated field of specified shape by illumination light, and a pattern image on a mask in an illuminated field of said specified shape is exposed to a substrate on a stage via a projection optical system, In a projection exposure method which exposes a pattern image of an area larger than an illuminated field of said specified shape on said mask on said substrate by scanning said mask and said substrate synchronously relatively to an illuminated field of said specified shape,
An alignment system of an off-axis method for detecting a position of a mark for positioning on said substrate near said projection optical system is arranged, Two or more marks for Measurement Division are formed towards said relative scan on said mask, The 1st and 2nd reference marks arrange a formed reference mark member on said stage at an interval corresponding to an interval of a reference point in an exposure field of said projection optical system, and a reference point of an alignment system of said off-axis method,
Where said 2nd reference mark on said reference member is observed by an alignment system of said off-axis method, Said mask is moved towards said relative scan, and the amount of position gaps of one mark for Measurement Division in two or more marks for Measurement Division on said mask and said 1st reference mark on said stage is measured one by one,
From the amount of position gaps of said 2nd reference mark observed by average value of each amount of position gaps of a mark for Measurement Division of said plurality, and said 1st reference mark, and an alignment system of said off-axis method. A projection exposure method searching for an interval of a reference point in an exposure field of said projection optical system, and a reference point of an alignment system of said off-axis method.
[Claim 3]On said reference mark member, make it correspond to two or more marks for Measurement Division on said mask, and form two or more said 1st reference mark, and. Two or more said 2nd reference mark is formed from the 1st reference mark of this plurality at an interval corresponding to an interval of a reference point in an exposure field of said projection optical system, and a reference point of an alignment system of said off-axis method, respectively,
Said mask and said stage are moved synchronizing with the direction of said relative scan, The amount of position gaps of one mark for Measurement Division in two or more marks for Measurement Division on said mask and said 1st corresponding reference mark on said stage is measured one by one, and a reference mark to which it corresponds of said two or more 2nd reference marks by an alignment system of said off-axis method is observed,
From average value of the amount of position gaps of two or more of said 2nd reference marks observed by average value of each amount of position gaps of a mark for Measurement Division of said plurality, and two or more of said 1st reference marks, and an alignment system of said off-axis method. A method of searching for an interval of a reference point in an exposure field of said projection optical system, and a reference point of an alignment system of said off-axis method according to claim 2.
[Claim 4]Illuminate an illuminated field of specified shape by illumination light, and a pattern image on a mask in an illuminated field of said specified shape is exposed to a substrate on a stage via a projection optical system, In a projection exposure method which exposes a

pattern image of an area larger than an illuminated field of said specified shape on said mask on said substrate by scanning said mask and said substrate synchronously relatively to an illuminated field of said specified shape,
A reference mark member which forms two or more marks for Measurement Division towards said relative scan on said mask and by which two or more reference marks were formed in a mark for Measurement Division of this plurality and an almost conjugate position is arranged on said stage,
Said mask and said substrate are moved synchronizing with the direction of said relative scan, The amount of position gaps of one mark for Measurement Division in two or more marks for Measurement Division on said mask and a corresponding reference mark on said stage is measured one by one, The 1st process of calculating each amount of position gaps of said mark for Measurement Division, and said reference mark; The amount of position gaps of one mark for Measurement Division predetermined [of two or more marks for Measurement Division on said mask] and a corresponding reference mark on said stage is measured only once, The 2nd process of calculating the amount of position gaps of said mark for Measurement Division, and said reference mark; One of said 1st process and said 2nd process is chosen, A projection exposure method having the 3rd process of asking for correspondence relation between a coordinate system on said mask, and a coordinate system on said stage based on each amount of position gaps of said mark for Measurement Division called for at a selected process, and said reference mark, and;.
[Claim 5]Illuminate an illuminated field of specified shape by illumination light, and a pattern image on a mask in an illuminated field of said specified shape is exposed to a substrate on a stage via a projection optical system, In a projection exposure method which exposes a pattern image of an area larger than an illuminated field of said specified shape on said mask on said substrate by scanning said mask and said substrate synchronously relatively to an illuminated field of said specified shape,
An alignment system of an off-axis method for detecting a position of a mark for positioning on said substrate near said projection optical system is arranged,
Two or more marks for Measurement Division are formed towards said relative scan on said mask, A reference mark member by which two or more reference marks were formed in a mark for Measurement Division of this plurality and an almost conjugate position is arranged on said stage, A reference mark of this plurality consists of the 1st and 2nd reference marks arranged at an interval corresponding to an interval of a reference point of said projection optical system, and a reference point of an alignment system of said off-axis method,
A projection exposure method comprising:
Where said 2nd reference mark on said reference mark member is observed by an alignment system of said off-axis method, Said mask is moved towards said relative scan, The 1st process of measuring the amount of position gaps of one mark for Measurement Division in two or more marks for Measurement Division on said mask, and said 1st reference mark one by one; where said 2nd reference mark on said reference mark member is observed by an alignment system of said off-axis method, The 2nd process of measuring the amount of position gaps of one mark for Measurement Division predetermined [of two or more marks for Measurement Division on said mask], and said 1st reference mark;. It is a measuring result in the 3rd process of choosing one of said 1st process and said 2nd process, and a process selected, at the; this 3rd process. It is the correspondence relation between a coordinate system on said mask, and a coordinate system on said stage from each amount of position gaps of said mark for Measurement Division, and said reference mark, and the amount of position gaps of said 2nd reference mark observed by an alignment system of said off-axis method.
The 4th process of searching for an interval of a reference point in an exposure field of said projection optical system, and a reference point of an alignment system of said off-axis method.;

[Claim 6]Illuminate an illuminated field of specified shape by illumination light, and a pattern image on a mask in an illuminated field of said specified shape is exposed to a substrate on a stage via a projection optical system, In a projection exposure method which exposes a

pattern image of an area larger than an illuminated field of said specified shape on said mask on said substrate by scanning said mask and said substrate synchronously relatively to an illuminated field of said specified shape,
An alignment system of an off-axis method for detecting a position of a mark for positioning on said substrate near said projection optical system is arranged,
Two or more marks for Measurement Division are formed towards said relative scan on said mask, A reference mark member by which two or more reference marks were formed in a mark for Measurement Division of this plurality and an almost conjugate position is arranged on said stage, A reference mark of this plurality consists of the 1st and 2nd reference marks formed at an interval corresponding to an interval of a reference point of said projection optical system, and a reference point of an alignment system of said off-axis method,
Whenever it carries out specified number exchange of said substrate,
Where said 2nd reference mark on said reference mark member is observed by an alignment system of said off-axis method, The amount of position gaps of one mark for Measurement Division predetermined [of two or more marks for Measurement Division on said mask] and said 1st corresponding reference mark is measured, From the measured this amount of position gaps, and the amount of position gaps of said 2nd reference mark observed by an alignment system of said off-axis method, correspondence relation between a coordinate system on said mask, and a coordinate system on said stage, A projection exposure method searching for an interval of a reference point in an exposure field of said projection optical system, and a reference point of an alignment system of said off-axis method.
[Claim 7]In a projection exposure method which carries out scanning exposure of said substrate using a pattern of said mask by moving synchronously each of a mask in which a pattern was formed, and a substrate as an exposure object,
In advance of said scanning exposure, the 1st stage holding said mask, and this 1st stage by holding said substrate independently, moving at least one side with the 2nd movable stage to a predetermined scanning direction, and moving said 1st stage and said 2nd stage relatively,
A projection exposure method searching for information for carrying out scanning exposure of said substrate.
[Claim 8]A scanning direction of said 1st stage is prescribed by the 1st interferometer systems that measure position information on said 1st stage,
A method according to claim 7, wherein a scanning direction of said 2nd stage is specified with the 2nd interferometer systems that measure position information on said 2nd stage.
[Claim 9]A method of moving each of said 1st stage and said 2nd stage to a mutually different scanning direction in said relative movement according to claim 7 or 8.
[Claim 10]A method according to claim 9, wherein said relative movement is performed like the time of scanning exposure of said substrate.
[Claim 11]A method according to claim 10, wherein said relative target synchronizes and moves said 1st stage and said 2nd stage in movement.
[Claim 12]A method according to claim 7 or 8, wherein said relative movement includes movement of only said 1st stage.
[Claim 13]A method of detecting a mark on said 1st stage and searching for information for carrying out scanning exposure of said substrate, while moving said 1st stage and said 2nd stage relatively according to any one of claims 7 to 12.
[Claim 14]A method according to claim 13, wherein two or more marks left to said scanning direction are arranged on said 1st stage.
[Claim 15]A method according to claim 13 or 14, wherein a mark on said 1st stage is detected with a mark on said 2nd stage.
[Claim 16]A method according to claim 15, wherein two or more marks left to said scanning direction are arranged on said 2nd stage.
[Claim 17]A method according to any one of claims 7 to 16, wherein information for carrying out scanning exposure of said substrate includes information for carrying out the synchronized drive of said mask and said substrate by position relations.
[Claim 18]A method according to any one of claims 7 to 17, wherein information for carrying out scanning exposure of said substrate is information about a correspondence relation with the 2nd coordinate system for controlling the 1st coordinate system for controlling

movement of said 1st stage, and movement of said 2nd stage.
[Claim 19]In a projection exposure method which carries out scanning exposure of the substrate using a pattern of said mask by moving synchronously a mask in which a pattern was formed, and a substrate as an exposure object,
A projection exposure method detecting two or more marks left and formed in a predetermined scanning direction at a reference member on the 1st stage holding either said mask or said substrates in advance of said scanning exposure, respectively.
[Claim 20]A method of moving said 1st stage to said scanning direction, in order to detect said two or more marks according to claim 19.
[Claim 21]In a projection exposure method which carries out scanning exposure of said substrate using a pattern of said mask by moving synchronously a mask in which a pattern was formed, and a substrate as an exposure object,
A projection exposure method detecting a mark formed in a reference member on said 1st stage while moving the 1st stage holding either said mask or said substrates to a predetermined scanning direction in advance of said scanning exposure.
[Claim 22]Claim 19, wherein said scanning direction is specified with the 1st interferometer systems that measure position information on said 1st stage, 20, or a method given in 21.
[Claim 23]Claim 19, wherein a mark on said reference member is detected with a mark on the 2nd stage holding another side of said mask and said substrates, 20, or a method given in 21.
[Claim 24]A method of asking for a correspondence relation with the 2nd coordinate system for controlling the 1st coordinate system for controlling movement of said 1st stage, and movement of said 2nd stage using a detection result of a mark on said reference member according to any one of claims 19 to 23.
[Claim 25]A method according to claim 24, wherein said 1st coordinate system is prescribed by the 1st interferometer systems that measure position information on said 1st stage and said 2nd coordinate system is specified with the 2nd interferometer systems that measure position information on said 2nd stage.
[Claim 26]In a projection exposure method which carries out scanning exposure of said substrate by moving synchronously each of a mask in which a pattern was formed, and a substrate as an exposure object,
In advance of said scanning exposure, two or more marks left to a predetermined scanning direction on the 1st stage holding either said mask or said substrate are detected, respectively, A projection exposure method asking for a correspondence relation with the 2nd coordinate system for controlling movement of the 2nd stage holding the 1st coordinate system for controlling movement of said 1st stage, and another side of said mask and said substrate.
[Claim 27]Said 1st coordinate system is prescribed by the 1st interferometer systems for measuring position information on said 1st stage,
A method according to claim 26, wherein said 2nd coordinate system is specified with the 2nd interferometer systems for measuring position information on said 2nd stage.
[Claim 28]A method according to claim 26 or 27, wherein a mark on said 1st stage is detected with a mark on said 2nd stage.
[Claim 29]A method according to claim 28, wherein two or more marks left to said scanning direction are arranged on said 2nd stage.
[Claim 30]A method according to claim 28 characterized by moving said 1st stage to said predetermined scanning direction in order to detect said two or more marks.
[Claim 31]A method of moving said 2nd stage to a different scanning direction from said 1st stage in parallel to movement of said 1st stage, in order to detect a mark on said 1st stage, and a mark on said 2nd stage according to claim 30.
[Claim 32]In a projection exposure method which exposes a substrate held at the 2nd stage using a pattern of a mask held at the 1st stage,
A projection exposure method choosing either of the 2nd mode in which a small number of marks on said 1st stage are detected from the number of marks detected in the 1st mode in which two or more marks on said 1st stage are detected, and this 1st mode.
[Claim 33]A method according to claim 32, wherein said 2nd mode detects a part of two or more marks detected in said 1st mode.

[Claim 34]A method according to claim 32 or 33, wherein a mark on said 1st stage is detected with a mark on said 2nd stage.
[Claim 35]A method of detecting a correspondence relation with the 2nd coordinate system for controlling the 1st coordinate system for controlling movement for said 1st stage by detecting a mark on said 1st stage, and a mark on said 2nd stage, and movement of said 2nd stage according to claim 34.
[Claim 36]A method of scanning [be / it / under / exposure / of said substrate / synchronization] said 1st stage and said 2nd stage according to claim 35.
[Claim 37]A method according to claim 36, wherein two or more marks left to a scanning direction specified by said 1st coordinate system are formed on said 1st stage.
[Claim 38]A method of asking for parallelism of a scanning direction specified by said 1st coordinate system by detecting two or more marks on said 1st stage in said 1st mode, and a scanning direction specified by said 2nd coordinate system according to claim 37.
[Claim 39]A method of asking for a correspondence relation with scaling of a scanning direction specified by scaling and said 2nd coordinate system of a scanning direction specified by said 1st coordinate system by detecting two or more marks on said 1st stage in said 1st mode according to claim 37.
[Claim 40]A method according to any one of claims 32 to 39 characterized by attaining selection in said 2nd mode after performing said 1st mode.
[Claim 41]A method of searching for a drawing error of said mask in said 1st mode, and applying this drawing error to said 2nd mode according to claim 40.
[Claim 42]In a projection aligner which carries out scanning exposure of said substrate using a pattern of said mask by moving synchronously each of a mask in which a pattern was formed, and a substrate as an exposure object,
The 1st stage that holds either said mask or said substrates, and moves,
The 2nd stage that holds another side of said mask and said substrates, and moves,
A control system which searches for information for carrying out scanning exposure of said substrate by moving at least one side of said 1st stage and said 2nd stage to a predetermined scanning direction, and carrying out relative displacement of said 1st stage and said 2nd stage in advance of said scanning exposure,
A projection aligner characterized for preparation ****** by things.
[Claim 43]A projection system which projects an image of a pattern of said mask on said substrate,
It has further a mark detection system which detects a mark on said 1st stage, and a mark on said 2nd stage via said projection system,
While said control system carries out relative displacement of said 1st stage and said 2nd stage, The device according to claim 42 said mark detection system's detecting a mark on said 1st stage, and a mark on said 2nd stage, and searching for information for carrying out scanning exposure of said substrate.
[Claim 44]Apart from said mark detection system, it has further an alignment system for detecting alignment information of said substrate,
On a stage holding said substrate, a mark detected by said mark detection system and a mark detected by said alignment system are arranged,
While said control system carries out relative displacement of said 1st stage and said 2nd stage, The device according to claim 43 performing detection by said mark detection system and said alignment system, and searching for physical relationship of a projection standard point of said projection system, and a detection reference point of said alignment system as information for carrying out scanning exposure of said substrate based on the detection result.
[Claim 45]The device according to claim 44 being separated from a projection standard point of said projection system, and a detection reference point of said alignment system to said scanning direction.
[Claim 46]In a projection aligner which carries out scanning exposure of said substrate using a pattern of said mask by moving synchronously a mask in which a pattern was formed, and a substrate as an exposure object,
A reference member by which two or more reference marks were left and formed in a

predetermined scanning direction,
A mark detection system for detecting said reference mark,
A projection aligner characterized by preparation ******.
[Claim 47]The device according to claim 46 having a transportation device which moves said reference member to said scanning direction in order to detect said two or more reference marks by said mark detection system, respectively.
[Claim 48]In a projection aligner which carries out scanning exposure of said substrate using a pattern of said mask by moving synchronously a mask in which a pattern was formed, and a substrate as an exposure object,
A reference member in which a reference mark was formed,
A mark detection system for detecting said reference mark,
A transportation device which moves said reference member to a predetermined scanning direction in order to detect said reference mark by said mark detection system,
A projection aligner characterized by preparation ******.
[Claim 49]Claim 46, wherein said reference member is provided on a stage holding either said mask or said substrates, 47, or a device given in 48.
[Claim 50]In a projection aligner which carries out scanning exposure of said substrate by moving each of a mask and a substrate synchronously,
A projection system which projects an image of a pattern of said mask on said substrate,
It has the detection position which separated towards a synchronized drive of said substrate to an optic axis of this projection system,
An alignment system which detects alignment information of said substrate,
A measurement means which measures physical relationship of a projection standard point of said projection system, and a detection reference point of said alignment system,
A projection aligner characterized by preparation ******.
[Claim 51]A reference member by which said measurement means has been arranged on a stage holding said substrate,
The device according to claim 50 having a mark detection system which detects a mark formed in said reference member via said projection system.
[Claim 52]Information acquired when said measurement means detects a mark on said reference member via said projection system according to said mark detection system, The device according to claim 51 characterized by measuring physical relationship of a projection standard point of said projection system, and a detection reference point of said alignment system based on information acquired by detecting a mark on said reference member according to said alignment system.
[Claim 53]In a projection aligner which carries out scanning exposure of said substrate by carrying out the synchronized drive of a mask in which a pattern was formed, and the substrate as an exposure object,
The 1st stage holding one object of said mask and said substrate,
The 2nd stage holding an object of another side of said mask and said substrate,
A mark detection system which detects two or more marks on said 1st stage that separated towards said synchronized drive and has been arranged in order to ask for a correspondence relation with the 2nd coordinate system for controlling the 1st coordinate system for controlling movement of said 1st stage, and movement of said 2nd stage in advance of scanning exposure of said substrate,
A projection aligner characterized by preparation ******.
[Claim 54]In a projection aligner which carries out scanning exposure of said substrate by carrying out the synchronized drive of a mask in which a pattern was formed, and the substrate as an exposure object,
The 1st stage holding one object of said mask and said substrate,
The 2nd stage holding an object of another side of said mask and said substrate,
A projection system which projects an image of a pattern of said mask on said substrate,
A mark detection system which detects two or more marks on said 1st stage that separated towards said synchronized drive and has been arranged, respectively,
An alignment system which is established apart from said mark detection system, and detects alignment information of said substrate,

While said mark detection system detects a mark on said 1st stage, and a mark on said 2nd stage, A control system which detects a mark on a stage which holds said substrate according to said alignment system, and measures physical relationship of a projection standard point of said projection system, and a detection reference point of said alignment system based on each detection result,
A projection aligner characterized by preparation ******.
[Claim 55]In an exposure device which exposes a substrate using a pattern of a mask,
The 1st stage holding said mask,
A mark detection system which can detect a mark on said 1st stage,
A control system which chooses whether the 2nd mode in which a small number of marks on said 1st stage are detected is performed from the number of marks detected by whether the 1st mode in which said mark detection system detects two or more marks on said 1st stage is performed, and said mark detection system in said 1st mode,
An exposure device characterized by preparation ******.
[Claim 56]The device according to claim 55 whenever said control system carries out exposing treatment of the substrate of a predetermined number, wherein it chooses said 2nd mode.
[Amendment 3]
[Document to be Amended]Description
[Item(s) to be Amended]0001
[Method of Amendment]Change
[Proposed Amendment]
[0001]
[Industrial Application]This invention relates, for example to the projection exposure method and device of a slit scan exposure system.
[Amendment 4]
[Document to be Amended]Description
[Item(s) to be Amended]0014
[Method of Amendment]Change
[Proposed Amendment]
[0014]In view of this point, in the projection exposure art of a slit scan exposure system, this invention reduces the influence of the drawing error of the pattern on reticle (mask), and an object of this invention is to enable it to perform correctly matching with a Reticulum mark system (mask coordinate system) and a wafer-coordinates system (substrate coordinate system). As for the exact halfbeak of the matching, depending on a process, quick nature may be thought as important about this. Then, an object of this invention is to enable it to perform matching with a Reticulum mark system (mask coordinate system) and a wafer-coordinates system (substrate coordinate system) by a high throughput.
[Amendment 5]
[Document to be Amended]Description
[Item(s) to be Amended]0015
[Method of Amendment]Change
[Proposed Amendment]
[0015]In the projection exposure art of a slit scan exposure system this invention, The influence of the drawing error of the pattern on reticle (mask) is reduced, and it aims also at enabling it to measure the amount of baselines which is an interval of the reference point of the exposure field of a projection optical system, and the reference point of the alignment system of an off-axis method with high precision.
[Amendment 6]
[Document to be Amended]Description
[Item(s) to be Amended]0016
[Method of Amendment]Change
[Proposed Amendment]
[0016]Also as for an exact halfbeak, whenever it exchanges the wafer of a specified number, for example, when performing base line measurement, quick nature may be thought as important and it is desirable to perform matching with a Reticulum mark system (mask

coordinate system) and a wafer-coordinates system (substrate coordinate system) simultaneously. Then, an object of this invention when measuring the amount of baselines for every predetermined wafer turnover rate is to enable it to perform matching with a Reticulum mark system (mask coordinate system) and a wafer-coordinates system (substrate coordinate system), and its base line measurement by a high throughput.

[Amendment 7]

[Document to be Amended]Description

[Item(s) to be Amended]0023

[Method of Amendment]Change

[Proposed Amendment]

[0023]In the premise part as an above-mentioned invention with the 6th same projection exposure method of this invention, The alignment system (34) of the off-axis method for detecting the position of the mark for positioning on a substrate (5) near the projection optical system (8) is arranged, Two or more marks for Measurement Division (29A, 29B, --) are formed towards the relative scan on a mask (12), The reference mark member (6) by which two or more reference marks were formed in the mark for Measurement Division of these plurality and the almost conjugate position is arranged on a stage (4), Whenever the reference mark of these plurality consists of the 1st (A [35],B [35], --) and 2nd (A [37],B [37], --) reference marks formed at the interval corresponding to the interval of the reference point of the projection optical system, and the reference point of the alignment system of the off-axis method and it carries out specified number exchange of the substrate (5), Where the 2nd reference mark (37A) on a reference mark member (6) is observed by the alignment system of the off-axis method, The amount of position gaps which measured the amount of position gaps of one mark for Measurement Division (29A) predetermined [of two or more marks for Measurement Division on a mask (12)], and the 1st corresponding reference mark (35A), and was measured in this way, From the amount of position gaps of the 2nd reference mark (37A) observed by the alignment system of the off-axis method, and the correspondence relation between the coordinate system on the mask, and the coordinate system on the stage, The interval (the amount of baselines) of the reference point in the exposure field of the projection optical system and the reference point of the alignment system of the off-axis method is searched for. The 7th projection exposure method of this invention next, by moving synchronously each of the mask in which the pattern was formed, and the substrate as an exposure object, In the projection exposure method which carries out scanning exposure of the substrate using the pattern of the mask, In advance of the scanning exposure, the 1st stage holding the mask, and this 1st stage by holding the substrate independently, moving at least one side with the 2nd movable stage to a predetermined scanning direction, and moving the 1st stage and its 2nd stage relatively, The information for carrying out scanning exposure of the substrate is searched for.The 8th projection exposure method of this invention by moving synchronously the mask in which the pattern was formed, and the substrate as an exposure object, In the projection exposure method which carries out scanning exposure of the substrate using the pattern of the mask, two or more marks left and formed in the predetermined scanning direction at the reference member on the 1st stage holding either the mask or its substrate are detected in advance of the scanning exposure, respectively.The 9th projection exposure method of this invention by moving synchronously the mask in which the pattern was formed, and the substrate as an exposure object, While moving the 1st stage holding either the mask or its substrate to a predetermined scanning direction in advance of the scanning exposure in the projection exposure method which carries out scanning exposure of the substrate using the pattern of the mask, The mark formed in the reference member on the 1st stage is detected. The 10th projection exposure method of this invention by moving synchronously each of the mask in which the pattern was formed, and the substrate as an exposure object, In the projection exposure method which carries out scanning exposure of the substrate, two or more marks left to the predetermined scanning direction on the 1st stage holding either the mask or its substrate are detected in advance of the scanning exposure, respectively, It asks for a correspondence relation with the 2nd coordinate system for controlling movement of the 2nd stage holding the 1st coordinate system and another side of the mask and a substrate for

controlling movement of the 1st stage. In the projection exposure method with which the 11th projection exposure method of this invention exposes the substrate held at the 2nd stage using the pattern of the mask held at the 1st stage, Either of the 2nd mode in which a small number of marks on the 1st stage are detected is chosen from the number of the marks detected in the 1st mode in which two or more marks on the 1st stage are detected, and this 1st mode. The 1st projection aligner of this invention next, by moving synchronously each of the mask in which the pattern was formed, and the substrate as an exposure object, In the projection aligner which carries out scanning exposure of the substrate using the pattern of the mask, The 1st stage that holds either the mask or its substrate, and moves, The 2nd stage that holds another side of the mask and its substrate, and moves, It has a control system which searches for the information for carrying out scanning exposure of the substrate by moving at least one side of the 1st stage and its 2nd stage to a predetermined scanning direction, and carrying out relative displacement of the 1st stage and its 2nd stage in advance of the scanning exposure. The 2nd projection aligner of this invention by moving synchronously the mask in which the pattern was formed, and the substrate as an exposure object, In the projection aligner which carries out scanning exposure of the substrate using the pattern of the mask, it has the reference member by which two or more reference marks were left and formed in the predetermined scanning direction, and a mark detection system for detecting the reference mark. The 3rd projection aligner of this invention by moving synchronously the mask in which the pattern was formed, and the substrate as an exposure object, In the projection aligner which carries out scanning exposure of the substrate using the pattern of the mask, In order to detect the reference mark by the reference member in which the reference mark was formed, mark detection system, and mark detection system for detecting the reference mark, it has a transportation device which moves the reference member to a predetermined scanning direction. When the 4th projection aligner of this invention synchronizes and moves each of a mask and a substrate, The projection system which projects the image of the pattern of the mask on the substrate in the projection aligner which carries out scanning exposure of the substrate, It has the detection position which separated towards the synchronized drive of the substrate to the optic axis of this projection system, and has an alignment system which detects the alignment information of the substrate, and a measurement means which measures the physical relationship of the projection standard point and the detection reference point of an alignment system of the projection system. When the 5th projection aligner of this invention carries out the synchronized drive of the mask in which the pattern was formed, and the substrate as an exposure object, The 1st stage that holds one object of the mask and its substrate in the projection aligner which carries out scanning exposure of the substrate, The 2nd stage holding the object of another side of the mask and its substrate and the scanning exposure of the substrate are preceded, In order to ask for a correspondence relation with the 2nd coordinate system for controlling the 1st coordinate system and movement of the 2nd stage for controlling movement of the 1st stage, it has a mark detection system which detects two or more marks on the 1st stage that separated towards the synchronized drive and has been arranged. When the 6th projection aligner of this invention carries out the synchronized drive of the mask in which the pattern was formed, and the substrate as an exposure object, The 1st stage that holds one object of the mask and its substrate in the projection aligner which carries out scanning exposure of the substrate, The 2nd stage holding the object of another side of the mask and its substrate, and the projection system which projects the image of the pattern of the mask on the substrate, The mark detection system which detects two or more marks on the 1st stage that separated towards the synchronized drive and has been arranged, respectively, While the alignment system which is established apart from the mark detection system, and detects the alignment information of the substrate, and its mark detection system detect the mark on the 1st stage, and the mark on the 2nd stage, The mark on the stage which holds the substrate according to the alignment system is detected, and it has a control system which measures the physical relationship of the projection standard point and the detection reference point of an alignment system of the projection system based on each detection result. In the exposure device with which the exposure device of this invention exposes a substrate using the pattern of a mask, The 1st stage

holding the mask, and the mark detection system which can detect the mark on the 1st stage, . [whether the 1st mode in which the mark detection system detects two or more marks on the 1st stage is performed, and] It has a control system which chooses whether the 2nd mode in which a small number of marks on the 1st stage are detected is performed from the number of the marks detected by the mark detection system in the 1st mode.
[Amendment 8]
[Document to be Amended]Description
[Item(s) to be Amended]0029
[Method of Amendment]Change
[Proposed Amendment]
[0029]
[Example]Hereafter, with reference to Drawings, it explains per 1st working example of this invention. This example applies this invention, when exposing the pattern of reticle on a wafer with the projection aligner of a slit scan exposure system. The illuminated field of the rectangle by exposing light EL from the illumination-light study system by which drawing 1 showed the projection aligner of this example, and figures omitted abbreviated was carried out in this drawing 1. The pattern on the reticle 12 is illuminated by (it is hereafter called "a slit shape illuminated field"), and projection exposure of the image of the pattern is carried out on the wafer 5 via the projection optical system 8. In this case, synchronizing with the reticle 12 being scanned with the constant speed V forward to the space of drawing 1 to the slit shape illuminated field of exposing light EL, the wafer 5 is scanned backward to the space of drawing 1 by constant speed V/M (1/M is the reducing magnification of the projection optical system 8).
[Amendment 9]
[Document to be Amended]Description
[Item(s) to be Amended]0122
[Method of Amendment]Change
[Proposed Amendment]
[0122]Although the technique of above-mentioned working example is explained about the base line measurement at the time of alignment of an off-axis method, it can expect the same effect by application of this invention also in the TTL (through the lens) method using the inside of the field of a projection optical system. Thus, this invention is not limited to above-mentioned working example, but can take various composition in the range which does not deviate from the gist of this invention. According to the above-mentioned projection exposure method, according to the called-for position gap, in each position of two or more marks for Measurement Division on a mask final, for example by the least squares approximation etc. By asking for the parameter (offset of magnification, scaling of a scanning direction, rotation, the parallelism of a scanning direction, the direction of X, and the direction of Y) which matches a mask coordinate system and a substrate coordinate system, the influence of the drawing error of the mark for Measurement Division on a mask can be suppressed small. According to the above-mentioned projection aligner, by equalizing the measuring result about two or more marks for Measurement Division by the side of a mask, the drawing error of the mark for Measurement Division of a mask is made small, and the amount of baselines which is an interval of the reference point of a projection optical system and the reference point of an alignment system can be measured correctly. According to the above-mentioned projection aligner, on a reference mark member, make it correspond to two or more marks for Measurement Division on a mask, and form two or more the 1st reference mark, and. Since two or more the 2nd reference mark is formed from the 1st reference mark of these plurality at the interval corresponding to the interval of the reference point in the exposure field of a projection optical system, and the reference point of the alignment system of an off-axis method, respectively, Since equalization is performed also the reference mark side, the amount of baselines is measured more correctly. According to the above-mentioned projection exposure method, it can ask for the correspondence relation between the coordinate system on a mask, and the coordinate system on a stage by a high throughput by choosing the simple measurement step by quick mode if needed. According to the above-mentioned projection exposure method, the correspondence relations and the

amount of baselines of the coordinate system on a mask and the coordinate system on a stage can be calculated by a high throughput by choosing the simple measurement step by quick mode if needed. Since according to the above-mentioned projection exposure method the simple measurement step by quick mode is performed whenever it exposes to the substrate of a specified number, When exposing by a scanning method continuously to many substrates, the correspondence relations and the amount of baselines of the coordinate system on a mask and the coordinate system on a stage can be calculated by a high throughput.

[Amendment 10]
[Document to be Amended]Description
[Item(s) to be Amended]0123
[Method of Amendment]Change
[Proposed Amendment]
[0123]
[Effect of the Invention]According to this invention, the influence of the drawing error of the mark for Measurement Division on a mask can be suppressed small.
[Amendment 11]
[Document to be Amended]Description
[Item(s) to be Amended]0124
[Method of Amendment]Change
[Proposed Amendment]
[0124]According to this invention, the amount of baselines which is an interval of the reference point of a projection optical system and the reference point of an alignment system is correctly measurable.
[Amendment 12]
[Document to be Amended]Description
[Item(s) to be Amended]0125
[Method of Amendment]Change
[Proposed Amendment]
[0125]According to this invention, it can ask for the correspondence relation between the coordinate system on a mask, and the coordinate system on a stage by a high throughput.
[Amendment 13]
[Document to be Amended]Description
[Item(s) to be Amended]0126
[Method of Amendment]Change
[Proposed Amendment]
[0126]According to this invention, the amount of baselines can be calculated by a high throughput.
[Amendment 14]
[Document to be Amended]Description
[Item(s) to be Amended]Drawing 1
[Method of Amendment]Change
[Proposed Amendment]
[Drawing 1]It is a lineblock diagram showing the projection aligner of one working example of this invention.

[Translation done.]

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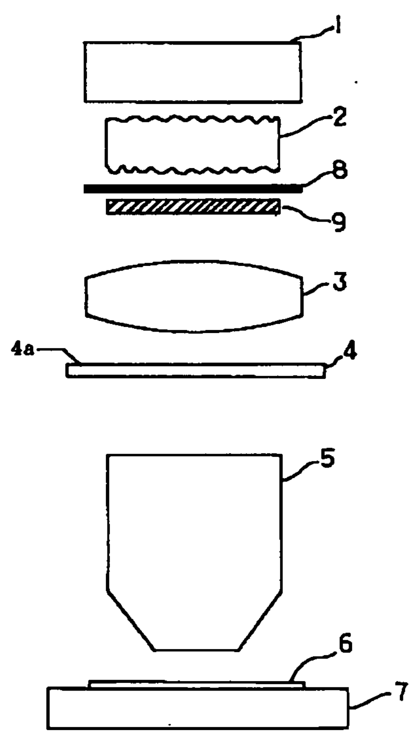
(54)【発明の名称】　結像方法及び該方法を用いる露光装置及び該方法を用いるデバイス製造方法

(57)【要約】

【目的】　周期性のパターンを最適な偏光状態の光束を用いて高解像度で投影するようにした結像方法及び該方法を用いる露光装置を得ること。

【構成】　照明系からの光束でレチクル面上の周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンの像をウエハ面上に投影する際、偏光装置により該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する直線偏光の光束を選択して投影していること。



【特許請求の範囲】

【請求項１】　ライン状のパターンを該パターンの長手方向に偏光した偏光ビームで結像していることを特徴とする結像方法。

【請求項２】　前記偏光ビームにより前記パターンを照明していることを特徴とする請求項１の結像方法。

【請求項３】　偏光していないビームにより前記パターンを照明し、前記パターンからのビームから前記偏光ビームを抽出していることを特徴とする請求項１の結像方法。

【請求項４】　前記パターンの結像が実質的に前記パターンからの２つの回折ビームにより行われていることを特徴とする請求項１，２又は３の結像方法。

【請求項５】　前記パターンに照明用のビームが斜入射していることを特徴とする請求項４の結像方法。

【請求項６】　前記パターンは位相シフターを備えていることを特徴とする請求項４の結像方法。

【請求項７】　ライン状のパターンを加工片上に前記ラインの長手方向に偏光した偏光ビームで結像し、該加工片上に前記パターンを転写してデバイスを製造していることを特徴とするデバイス製造方法。

【請求項８】　前記偏光ビームにより前記パターンを照明していることを特徴とする請求項７のデバイス製造方法。

【請求項９】　非偏光ビームにより前記パターンを照明し、前記パターンからのビームから前記偏光ビームを抽出していることを特徴とする請求項７のデバイス製造方法。

【請求項１０】　前記パターンの結像が実質的に前記パターンからの２つの回折ビームにより行われていることを特徴とする請求項７のデバイス製造方法。

【請求項１１】　前記パターンに照明用のビームが斜入射していることを特徴とする請求項１０のデバイス製造方法。

【請求項１２】　前記パターンは位相シフターを備えていることを特徴とする請求項１０のデバイス製造方法。

【請求項１３】　ライン状のパターンを照明手段により前記パターンの長手方向に偏光した偏光ビームで照明し、前記照明手段からの偏光ビームで照明された前記パターンを投影手段により基板上に投影し、露光するようにしたことを特徴とする露光装置。

【請求項１４】　前記照明手段は前記パターンに前記偏光ビームを斜入射させていることを特徴とする請求項１３の露光装置。

【請求項１５】　ライン状のパターンを照明手段により非偏光ビームで照明し、前記照明手段からの非偏光ビームで照明された前記パターンを投影手段により前記パターンの長手方向に偏光した偏光ビームにより基板上に投影し、露光するようにしたことを特徴とする露光装置。

【請求項１６】　前記照明手段は前記パターンに前記非偏光ビームを斜入射させていることを特徴とする請求項１５の露光装置。

【請求項１７】　繰り返しパターンを繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームで結像していることを特徴とする結像方法。

【請求項１８】　前記偏光ビームにより前記パターンを照明していることを特徴とする請求項１７の結像方法。

【請求項１９】　偏光していないビームにより前記パターンを照明し、前記パターンからのビームから前記偏光ビームを抽出していることを特徴とする請求項１７の結像方法。

【請求項２０】　前記パターンはラインとスペースより成るパターンを含んでいることを特徴とする請求項１７の結像方法。

【請求項２１】　前記パターンはドット状のパターンを含んでいることを特徴とする請求項１７の結像方法。

【請求項２２】　前記パターンの結像が実質的に前記パターンからの２つの回折ビームにより行われていることを特徴とする請求項１７，１８，１９，２０又は２１の結像方法。

【請求項２３】　前記パターンに照明用のビームが斜入射していることを特徴とする請求項２２の結像方法。

【請求項２４】　前記パターンは位相シフターを備えていることを特徴とする請求項２２の結像方法。

【請求項２５】　繰り返しパターンを加工片上に前記繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームで結像し、該加工片上に前記繰り返しパターンを転写し、デバイスを製造していることを特徴とするデバイス製造方法。

【請求項２６】　前記偏光ビームにより前記パターンを照明していることを特徴とする請求項２５のデバイス製造方法。

【請求項２７】　非偏光ビームにより前記パターンを照明し、前記パターンからのビームから前記偏光ビームを抽出していることを特徴とする請求項２５のデバイス製造方法。

【請求項２８】　前記パターンはラインとスペースより成るパターンを含んでいることを特徴とする請求項２５のデバイス製造方法。

【請求項２９】　前記パターンはドット状のパターンを含んでいることを特徴とする請求項２５のデバイス製造方法。

【請求項３０】　前記パターンの結像が実質的に前記パターンからの２つの回折ビームにより行われていることを特徴とする請求項２５，２６，２７，２８又は２９のデバイス製造方法。

【請求項３１】　前記パターンに照明ビームが斜入射していることを特徴とする請求項３０のデバイス製造方法。

【請求項３２】　前記パターンは位相シフターを備えて

いることを特徴とする請求項３０のデバイス製造方法。

【請求項３３】　繰り返しパターンを照明手段により前記繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームで照明し、前記照明手段からの偏光ビームで照明された前記パターンを投影手段により基板上に投影し、露光するようにしたことを特徴とする露光装置。

【請求項３４】　前記照明手段は前記パターンに前記偏光ビームを斜入射させていることを特徴とする請求項３３の露光装置。

【請求項３５】　繰り返しパターンを照明手段により非偏光ビームで照明し、前記照明手段からの非偏光ビームで照明された前記パターンを投影手段により繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームにより基板上に投影し、露光するようにしたことを特徴とする露光装置。

【請求項３６】　前記照明手段は前記パターンに前記非偏光ビームを斜入射させていることを特徴とする請求項３５の露光装置。

【請求項３７】　周期性のあるパターンを該パターンの周期方向に対応した直線偏光の光束で照明し、該パターンを投影光学系により所定面上に投影するようにしたことを特徴とする像投影方法。

【請求項３８】　周期性のあるパターンを該パターンの配列方向と直交する方向に偏光面を有する直線偏光の光束で照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンを所定面上に投影するようにしたことを特徴とする像投影方法。

【請求項３９】　照明系からの光束を直線偏光の偏光方向を任意に変えて射出させることができる偏光装置を介して周期性のあるパターンをその周期が最短となる方向に対して略直交する方向に偏光面を有する光束で照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンを所定面上に投影するようにしたことを特徴とする像投影方法。

【請求項４０】　照明系からの光束でレチクル面上の周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンの像をウエハー面上に投影する際、該パターンを該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する直線偏光の光束で照明していることを特徴とする露光装置。

【請求項４１】　周期性のあるパターンを照明し、該パターンを投影光学系により所定面上に投影する際、該パターンの周期方向に対応した直線偏光の光束を用いて投影していることを特徴とする像投影方法。

【請求項４２】　周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて該パターンを所定面上に投影する際、該パターンの配列方向と直交する方向に偏光面を有する直線偏光の光束を用いて投影していることを特徴とする像投影方法。

【請求項４３】　照明系からの光束で周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて該パターンを所定面上に投影する際、偏光装置により該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する光束を選択して該パターンの投影を行っていることを特徴とする像投影方法。

【請求項４４】　照明系からの光束でレチクル面上の周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンの像をウエハー面上に投影する際、偏光装置により該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する直線偏光の光束を選択して投影していることを特徴とする露光装置。

【請求項４５】　回路パターンを持った原版とウエハーとを用意する工程と、請求項３７，３８，３９，４１，４２，４３のいずれかの方法によって原版の回路パターンをウエハーに露光転写する工程を有することを特徴とする半導体素子製造方法。

【請求項４６】　請求項４５の製造方法によって製造されたことを特徴とする半導体素子。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、結像方法及び該方法を用いる露光装置及び該方法を用いるデバイス製造方法に関する。

【０００２】特に本発明は、ＩＣやＬＳＩ、ＣＣＤ、液晶パネル、磁気ヘッド等の各デバイスを製造する際に有用な結像方法及び該方法を用いる露光装置及び該方法を用いるデバイス製造方法に関する。

【０００３】この他本発明は、半導体素子の製造装置であるステッパーにおいてレチクル又はマスク（以下「レチクル」と称する）面上の線幅の小さい電子回路パターン（パターン）を適切なる光束で照明し、ウエハー面上に高い解像力で投影することができる像投影方法及びそれを用いた露光装置に関するものである。

【０００４】

【従来の技術】ＩＣ、ＬＳＩ等の半導体チップの高集積化に対する要求が高まっているので紫外光により照明した回路パターンを縮小投影して転写を行う所謂ステッパー（縮小投影露光装置）の解像力の向上のために様々な改良がなされている。

【０００５】従来、解像力を高める方法として、縮小投影レンズ系の開口数（ＮＡ）を大きくする方法、及び露光光の波長を短くする方法等が採られてきた。又、最近では、これらの方法とは別に位相シフト法や斜入射照明方法等、特に周期性のある微細パターン（繰り返し微細パターン）を結像するために有効な手法が提案されている。

【０００６】周期性のある微細なパターンの結像について、以下に説明する。

【０００７】図３２は、３本の微細なスリットから成る繰り返しパターンを示すグラフであり、グラフの横軸にパターン位置Xを、縦軸に振幅透過率Tをとっている。図中、透過率１の部分は光が透過し、透過率０の部分は光が遮られる。

【０００８】このような振幅透過率をもつ繰り返しパターンをコヒーレントな光で照明すると、入射光は０次，＋１次，－１次、及び他の高次の回折光へと分かれる。このうち像の形成に寄与するのは投影光学系の瞳に入射する回折光のみであり、一般には０次，＋１次，－１次の回折光が投影光学系の瞳に入射する。

【０００９】図３３は０次、，±１次の回折光の瞳上における振幅を示す説明図である。図中１００，１０１，１０２はそれぞれ０次，＋１次，－１次の回折光のピーク位置を、ＩＡは振幅を表す。

【００１０】図３４は０次、±１次の回折光により形成されるパターン像の強度分布を示している。縦軸は強度Ｉを示している。通常の結像では、パターンの線幅が非常に小さくなって０次の回折光しか投影光学系の瞳に入射しなくなると、もはやパターンの像は形成されなくなってしまう。

【００１１】これに対して位相シフト法では、光が上記繰り返しパターンを透過する際、隣合うスリットからの回折光の位相が１８０度ずれるようにパターンに細工をすることにより、投影光学系の瞳上で０次の回折光成分が現れないようにし、パターンの像を＋１次と－１次の回折光によって形成している。

【００１２】３本の微細スリットから成る繰り返しパターンを、位相シフト法を用いて投影した際に投影光学系の瞳上にできる振幅分布を図３５に示す。図中１０３，１０４はそれぞれ＋１次，－１次の回折光成分のピーク位置を表す。この場合パターンの繰り返し周期を同じとすればピーク位置１０３，１０４間の距離が図３３の±１次の回折光のピーク位置間の距離に比べて半分になる。位相シフト法を用いると、パターンの空間周波数を見掛け上小さくすることができるので、より微細なパターンからの±１次の回折光が瞳上に入射する。従って、解像度が向上する。

【００１３】図３３の瞳上の振幅分布は、パターンが描かれた平面に対して垂直な方向から光を入射させた場合のものであるが、この平面に斜めから光を入射させることによって、瞳上に振幅分布の位置を横方向にずらすのが斜入射法である。

【００１４】図３６は瞳上に０次と＋１次の回折光が入るように繰り返しパターンに光を斜入射させたときの瞳上の振幅分布を示す説明図である。図中１０５，１０６はそれぞれ０次，＋１次の回折光のピーク位置を表す。

【００１５】図３６に示す２つの回折光によって像を形成することを考えれば、斜入射法でも、位相シフト法の場合と同様に、より微細なパターンからの回折光が瞳上に到達でき、解像度が向上する。

【００１６】

【発明が解決しようとする課題】前述した位相シフト法や斜入射照明法による解像度の向上の効果には周期性のパターンを照明する場合、光の偏光状態が大きくかかわっていることが本発明者の行ったシュミレーションの結果から明らかになった。そのため、照明光の偏光状態をパターンに対して最適な状態にしないと、位相シフト法や斜入射照明法等を用いても大きな解像度の向上が得られないという問題点が生じてくる。

【００１７】本発明の目的は、微細パターンを結像するのに好適な改良された結像方法及び該方法を用いる露光装置及び該方法を用いてデバイス製造する方法を提供することにある。

【００１８】この他、本発明は周期性のあるパターンを投影光学系で所定面上に投影する際、投影に用いる光束の偏光状態をパターンの周期方向に対応させて適切に設定することにより、高い解像力を維持しつつ高いコントラストで投影することができる半導体素子の製造に好適な像投影方法及びそれを用いた露光装置の提供を目的とする。更には高集積度の半導体素子の製造方法の提供を目的とする。

【００１９】

【課題を解決するための手段】（１－１）本発明の第１の形態は、ライン状のパターンを結像する結像方法において、前記パターンの長手方向に偏光した偏光ビームで前記パターンを結像せしめることを特徴とする。

【００２０】（１－２）本発明の第２の形態は、ライン状のパターンを加工片上に結像し、該加工片上に前記パターンを転写するデバイス製造方法において、前記パターンの長手方向に偏光した偏光ビームで前記パターンを結像せしめることを特徴とする。

【００２１】（１－３）本発明の第３の形態は、ライン状のパターンで基板を露光する露光装置において、前記パターンの長手方向に偏光した偏光ビームにより前記パターンを照明する手段と前記照明手段により照明された前記パターンを前記基板上に投影する手段とを有することを特徴とする。

【００２２】（１－４）本発明の第４の形態は、ライン状のパターンで基板を露光する露光装置において、前記パターンを非偏光ビームで照明する照明手段と前記照明手段により照明された前記パターンを前記パターンの長手方向に偏光した偏光ビームにより前記基板上に投影する投影手段とを有していることを特徴とする。

【００２３】（１－５）本発明の第５の形態は、繰り返しパターンを結像する結像方法において、繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームで前記パターンを結像せしめることを特

徴とする。

【００２４】（１－６）本発明の第６の形態は、繰り返しパターンを加工片上に結像し、該加工片上に前記繰り返しパターンを転写するデバイス製造方法において、繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームで前記パターンを結像していることを特徴としている。

【００２５】（１－７）本発明の第７の形態は、繰り返しパターンで基板を露光する露光装置において、繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームにより前記パターンを照明する照明手段と前記照明手段により照明された前記パターンを前記基板上に投影する投影手段とを有することを特徴とする。

【００２６】（１－８）本発明の第８の形態は、繰り返しパターンで基板を露光する露光装置において、前記パターンを非偏光ビームで照明する照明手段と前記照明手段により照明された前記パターンを繰り返しの周期が最も小さくなる方向と実質的に直交する方向に偏光した偏光ビームにより前記基板上に投影する手段とを有することを特徴とする。

【００２７】（１－９）本発明において、偏光ビームでパターンを照明するときには、当該パターンが形成された基板上に偏光板（膜）を形成したり、偏光ビームを発するレーザー等の光源を設けたり、この照明の為の光学系中に偏光板（膜）を設ける。

【００２８】また、本発明において、非偏光ビームで照明されたパターンを偏光ビームで結像するときには、当該パターンが形成されたマスク等の基板上に偏光板（膜）を形成したり、この結像の為の光学系中に偏光板（膜）を設ける。

【００２９】本発明の好ましい形態では、上記照明光学系又は結像光学系の偏光板（膜）の方位を変え得るよう当該偏光板（膜）を系の光軸の回りに回転できるよう構成する。この構成により所望の方向に偏光した偏光ビームが形成できる。

【００３０】本発明の別の好ましい形態では、上記照明光学系又は結像光学系中に１／２波長板（膜）を設け、当該１／２波長板（膜）の光学軸の方位を変え得るよう当該１／２波長板（膜）を系の光軸の回りに回転できるよう構成する。この構成により所望の方向に偏光した偏光ビームが形成できる。

【００３１】又、本発明において、基板上に相異なるパターンが形成されており、これらのパターンの長手方向が互いに異なっていたり、これらのパターンの繰り返しの周期が最も小さい方向（最小周期方向）が互いに異なっているときには、夫々のパターンの長手方向又は／及び最小周期方向に直交する方向、に対応した偏光ビームにより各パターンを結像する。

【００３２】このような結像を同時に行うとき各パターン毎にそれらに対応した偏光板（膜）を設けた状態で非偏光ビームを供給したり、一つのパターン以外の他のパターンにそれ又はそれらに対応した偏光を生じさせる為の１／２波長板（膜）を設けた状態で前記一つのパターンに対応した偏光ビームを供給したりする。この偏光板（膜）や１／２波長板（膜）はパターンの光入射側又は光射出側の少なくとも一方に設けるとよい。

【００３３】このような結像を順次行うとき、照明光学系又は結像光学系を前記の好ましい形態の如く構成し、各パターンに対応する偏光ビームを発生させる。

【００３４】本発明の好ましい形態では前記パターンが照明ビームにより斜方向から照明されたり、前記パターンに位相シフターが供給されたりし、前記パターンからの実質的に２つの回折ビームにより結像が行われる。

【００３５】（１－１０）本発明の像投影方法は

（１－１０－イ）周期性のあるパターンを該パターンの周期方向に対応した直線偏光の光束で照明し、該パターンを投影光学系により所定面上に投影するようにしたことを特徴としている。

【００３６】（１－１０－ロ）周期性のあるパターンを該パターンの配列方向と直交する方向に偏光面を有する直線偏光の光束で照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンを所定面上に投影するようにしたことを特徴としている。

【００３７】（１－１０－ハ）照明系からの光束を直線偏光の偏光方向を任意に変えて射出させることができる偏光装置を介して周期性のあるパターンをその周期が最短となる方向に対して略直交する方向に偏光面を有する光束で照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンを所定面上に投影するようにしたことを特徴としている。

【００３８】（１－１０－ニ）周期性のあるパターンを照明し、該パターンを投影光学系により所定面上に投影する際、該パターンの周期方向に対応した直線偏光の光束を用いて投影していることを特徴としている。

【００３９】（１－１０－ホ）周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて該パターンを所定面上に投影する際、該パターンの配列方向と直交する方向に偏光面を有する直線偏光の光束を用いて投影していることを特徴としている。

【００４０】（１－１０－ヘ）照明系からの光束で周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて該パターンを所定面上に投影する際、偏光装置により該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する光束を選択して該パターンの投影を行っていることを特徴としている。

【００４１】（１－１１）又、本発明の露光装置としては

（１－１１－イ）照明系からの光束でレチクル面上の周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンの像をウエハー面上に投影する際、該パターンを該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する直線偏光の光束で照明していることを特徴としている。

【００４２】（１－１１－ロ）照明系からの光束でレチクル面上の周期性のあるパターンを照明し、該パターンから生じる回折光を投影光学系の瞳に入射させて、該パターンの像をウエハー面上に投影する際、偏光装置により該パターンの周期が最短となる方向に対して略直交する方向に偏光面を有する直線偏光の光束を選択して投影していることを特徴としている。

【００４３】

＊【実施例】まず本発明の各実施例を説明する前に、一般的な結像特性のシュミレーションに用いられる所謂スカラー回折理論と、本発明者がシュミレーションに用いた上記スカラー回折理論よりも精度の高い理論について説明する。

【００４４】スカラー回折理論では、物体のパターンが照明されると、そのパターンのフーリエ変換像が投影光学系の入射瞳上に形成され、このフーリエ変換像を投影光学系の開口数（ＮＡ）の範囲内で再びフーリエ変換して、像面上にある振幅分布のパターン像が形成される。これを式で表現すると、像面上の点（ｘ，ｙ）における振幅Ａ（ｘ，ｙ）は

【００４５】

【数１】

＊

$$A(x,y)=\iint F\left(U(x_1,y_1)\right)\exp\left\{ik(\alpha x+\beta y)\right\}d\alpha d\beta$$

と書ける。

式中Ｆ（Ｕ（x_1，y_1））はパターンの振幅透過率Ｕ（x_1，y_1）のフーリエ変換であり、このフーリエ変換を投影光学系の開口数で決まる瞳面の範囲内で再びフーリエ変換している。但し式中（α，β）は瞳面上の座標であり、Ｆ（Ｕ（x_1，y_1））は（α，β）の関数になっている。

【００４６】この式は照明光がコヒーレントな場合の式であるが、照明光が部分コヒーレントな場合にも、扱いは多少複雑になるが、基本的には同じである。

【００４７】上に述べた式を用いたシュミレーションでは、投影光学系の開口数が小さい場合は正しい結果が得られるが、その開口数が大きくなるといくつかの問題が生じることが、本発明者の行った検討により、明らかになった。

【００４８】上式の一番の問題点は入射光の偏光状態が考慮されていないことである。このことを図を用いて説明する。説明には前述の３本のスリットより成る繰り返しパターンの例を用いる。

【００４９】図２６は図３３で示した瞳上の振幅分布を、投影光学系のガウス像点１１０を基準とした参照球面１１１上に描いている。像面１１２上の点１１０における振幅は、投影光学系の波面収差を無視すれば参照球面１１１上の振幅の積分によって決まり、又、像面１１２上で点１１０から距離ｘだけずれた点における振幅は、距離ｘと参照球面１１１上の座標から決まる、ある位相差を考えて参照球面１１１上の振幅を、積分することによって計算される。

【００５０】ここから先は、話を簡単にするために、点１１０における振幅の計算に議論を限ることにする。又、ここで座標軸の定義を行っておく。

【００５１】図２６に示すように光軸をｚ軸とし、紙面内でｚ軸に垂直な軸をｘ軸、及び紙面に垂直な方向の軸をｙ軸とする。上に述べたスカラー回折理論による考え方では、点１１０における振幅は参照球面１１１上の振幅をそのまま足し合わせた形で計算される。

【００５２】光には偏光というものがあり、例え完全にコヒーレントな光同士であっても、その偏光方向が異なっていると完全には干渉しないし、それが例えば直交していると干渉は全く起こらない。

【００５３】繰り返しパターンを構成するスリットの長手方向がｙ軸に平行で、繰り返しパターンがｘ軸方向に周期を持つとして、ｚ軸に平行な方向から光でスリットを照明すれば参照球面１１１上では図２６の振幅分布が形成される。照明光がｙ軸方向（スリットに平行な方向）に偏光した直線偏光光であり、投影光学系内で偏光方向の変化が無視できるとすれば、上記の振幅分布の各点における偏光方向も、照明光と同様に全ての位置でｙ軸方向となる。

【００５４】スリットで回折された光のうちｙ軸方向に偏光した光のみで参照球面１１１上の振幅分布が形成されているとすると、像面１１２上に達する光の偏光方向もすべて同一となる。この場合も、点１１０における振幅は参照球面１１１上の振幅をそのまま積分することによって求まる。

【００５５】一方、照明光がｘ軸方向（スリットに直交する方向）に偏光した直線偏光光である場合は図２７に示すように、参照球面１１１から点１１０に向けた代表的な光線１２０～１２４を考えた場合、偏光方向と光の進行方向は直交するという条件から、光線１２０～１２４の偏光方向はそれぞれ図中１２５～１２９の矢印のようになる。この場合の偏光はｘ，ｚ両偏光成分を持っており、点１１０における振幅はそれぞれの偏光成分毎に考える必要がある。点１１０における光の強度はそれぞれの偏光成分による振幅から得られる強度の合計となる。

【００５６】次にこの考え方を適用してシュミレーショ

ンを行った結果について説明する。まず図３３で説明した０次，＋１次，－１次の回折光成分を用いる結像では、照明光の２つの偏光方向に対して、即ちスリットから回折される光のうちｘ軸方向とｙ軸方向のどちらの方向の偏光成分を用いるかによって得られる最終的な強度分布はそれぞれ図２８，図２９のようになる。

【００５７】図２８は照明光の偏光方向がスリットに平行な場合であり、像はｙ軸方向の偏光成分のみで形成される。一方、図２９は照明光の偏光方向がスリットに垂直な場合であり、像はｘ偏光成分及びｚ偏光成分の合計として形成される。

【００５８】同様のシュミレーションによって、位相シフト法や斜入射照明法のように、０次，＋１次，－１次の３つの回折光のうちの２つの回折光を用いる結像を評価したものを、次に示す。

【００５９】像面上の強度分布の結果のみを示すと、照明光の偏光方向がｙ軸方向（スリットに平行）の場合は図３０に示す強度分布に、偏光方向がｘ軸方向（スリットに垂直）の場合は図３１に示す強度分布になる。

【００６０】ここでは、偏光方向がスリットに垂直な場合はｚ方向の偏光成分の影響で、偏光方向がスリットに平行な場合に比べて、像のコントラストがかなり悪い。通常の露光では照明光は無偏光の状態になっているので、強度分布は図３０，図３１の強度分布を平均したものになるが、その場合でも図３１の強度分布に比べてコントラストが劣化する。

【００６１】このように、照明光の偏光方向が結像特性に大きな影響を与えることが本発明者の行った精度の高いシュミレーションの結果から明らかになった。

【００６２】特に、解像度を高めるために位相シフト法、又は斜入射照明法を適用した場合に、投影する周期性のあるパターンに対して照明光の偏光方向を適切に制御することにより、期待以上の解像度が得られる。

【００６３】以上が本発明が行った結像特性に関するシュミレーションの結果である。

【００６４】次に本発明の各実施例について説明する。

【００６５】図１は本発明の像投影方法を半導体素子やＣＣＤや液晶パネルや磁気ヘッド等のデバイス製造用のステッパー（ステップ＆リピート型投影露光装置）に適用したときの実施例１の要部概略図である。

【００６６】図中、１は超高圧水銀灯等の光源である。光源１から出た光はオプティカルインテグレーター２によって光量分布が均一化された、アパーチャー８と偏光装置９を介して照明レンズ３によりレチクル４面上のパターン（回路パターン）４ａを照明する。レチクル４のパターン４ａで回折された光は、投影レンズ５に入射し、投影レンズ５を介してステージ７の上に載った半導体ウエハーー６上にパターン４ａの像を形成している。

【００６７】ここでオプティカルインテグレーター２から射出した光は、その全ての光束が照明レンズ３に到達するのではなく、オプティカルインテグレーター２に接近して置かれた開口絞りである所のアパーチャー８によって照明に適した部分のみが選択され、選択された光は偏光装置９を透過する際、その偏光状態が円又は楕円偏光又は非偏光の状態から直線偏光に変換される。偏光装置９は、直線偏光の偏光方向をパターン４ａの繰り返しの方向等の条件に応じて変えることができる。

【００６８】レチクル４には、樽体ウエハーー６上への転写を行うための線幅の小さい回路パターン４ａが描かれており、照明レンズ３を介してレチクル４に入射する照明光は上記回路パターン４ａに応じてレチクル４を透過する。半導体ウエハーー６上にはレジスト等の感光材料が塗布されており、そこに回路パターン４ａの像を転写することが可能になっている。

【００６９】投影レンズ５はレチクル４上の回路パターン４ａの像を半導体ウエハーー６上に所定の倍率に縮小（一般に１／５又は１／１０）して投影している。その際、レチクル４と半導体ウエハーー６は、ステージ７を駆動することによって所定の位置関係に調整される。半導体ウエハーー６上のあるショットへの露光が終了すると、半導体ウエハー６はステージ７によって水平方向に所定量移動され、そこで、半導体ウエハーー６上の他ショットの露光を行うことを繰り返す。

【００７０】本実施例ではレチクル４上の回路パターン４ａとして図２に示すｙ方向に延びるスリットを５本ｘ方向に並べた、ｘ方向に周期性を有する繰り返しパターンを用いている。図中１０～１４が開口で、この開口１０～４の周囲は遮光部より成り、光はこの部分のみを透過する。又、一点鎖線１５はスリット状の開口１０～１４の繰り返し方向（ｘ方向）に引いた基準線であり、後の説明で用いる。

【００７１】ここでは、主光線がレチクル４に対して鉛直な方向から傾いた光束でレチクル４を照明することにより像のコントラストを向上させる。

【００７２】図３は図２のパターン４ａの一点鎖線１５に沿った断面図である。斜入射照明法により光束２０，２１を傾ける方向としては、図３に示すようにパターン４ａが繰り返しているＺＸ平面内で光束の主光線が斜めになるようにする。この条件を満たすべく、本実施例ではアパーチャー８の開口を図４に示すよう構成している。尚、ｘ軸はパターン４ａの繰り返しの周期が最も小さくなる方向に向いている。

【００７３】図４において斜線部分２２は光が通らないように遮光されている遮光領域である。２つの円形開口２３，２４は光透過領域であり、この領域２３，２４からの光がパターン４ａの結像に寄与する。図中、２５は円形開口２３，２４の中心を通るように引いた基準線である。

【００７４】図１のアパーチャー８で選択された照明光は次に、偏光装置９に入射する。偏光装置９は図５に示

すように、偏光装置９の上面から入射する光の偏光成分のうち、図中矢印２６で示したｙ方向の偏光光のみを透過させ、他の方向の偏光光は遮るような構造になっている。図中一点鎖線２７は上記矢印２６に直交する方向に引いた基準線である。図１のレチクル４、アパーチャー８、そして偏光装置９の水平面内での配置は、図２，４，５中にそれぞれ示した基準線１５，２５，２７がお互いに平行になるように設定している。

【００７５】以上のような構成により、斜入射照明光の偏光方向をパターン４ａのスリット方向に平行なｙ方向になるようにして、即ちパターン４ａの繰り返しの周期が最小となるｘ方向に直交するようにして、パターン４ａの結像と焼付けを行うことにより、図３０で説明したように高解像度で、かつコントラストの高い像を半導体ウエハーー６上に得ている。レチクル４上のパターンとしてドット上の繰り返しパターンの場合も、同様の効果がある。

【００７６】次に本実施例において、レチクル４上のパターン４ａが、図２のように１方向に周期性のある単一パターンのみでなく、図６に示すように各々が縦、横の（ｙ，ｘ）の２方向に周期性のある２つのパターンを持っている場合について説明する。

【００７７】この場合、図６の破線３０で囲まれた部分の繰り返しパターンは上述の方法を用いることにより、良好に投影転写を行うことができる。しかしながら破線３１で囲まれた部分の繰り返しパターンについては照明光の偏光方向がスリットに直交する方向になるので同じような効果は得られない。

【００７８】そこで本実施例では、図６のレチクルを図７と図８に示す２枚のレチクルに分割し、別々に露光している。即ち図７のパターンについては前述した通り、ｙ方向に偏光した直線偏光光で焼付けを行い、図８のパターンについては、パターンが繰り返す平面内で照明光がレチクルに斜入射し、かつ照明光の偏光方向がスリットの長手方向に平行な方向となるように、即ちｘ方向に偏光した直線偏光光となるように、不図示の駆動装置によりアパーチャー８と偏光装置９を水平面内で光軸を中心に９０度回転させてから固定してから焼付けを行っている。この方法はスリットのパターンが縦、横の２方向に限らず、他の方向になった場合も同様に適用可能である。

【００７９】又、図６に示すように一つのレチクルに２種類の繰り返しパターンがある場合、レチクルと共役な場所に設けたマスキングブレードを用いて各パターンを順次照明するようにし、上記方法で各パターンを偏光光で照明する。

【００８０】本実施例ではレチクル上のパターンは５本のライン＆スペースで形成されているとして説明を行ったが、５本以外のライン＆スペースパターンについても同様に適用可能である。又、ライン＆スペースの幅の比は１対１に限られるものではなく、更にパターンの周期がある程度不規則になった場合でも本発明は同様に適用可能である。

【００８１】又、本実施例において偏光装置９を照明レンズ３とレチクル４との間又はレチクル４と投影レンズ５との間又は投影レンズ５の内部（瞳面上）に配置しても良い。

【００８２】偏光装置９をレチクル４と投影レンズ５との間に配置したときは、偏光装置９によってレチクル４上のパターン形状に応じてパターン４ａで回折された回折光のうち、特定の方向に偏光した偏光光が選択され、この選択された偏光光束のみが投影レンズ５に入射するようになる。そしてこの偏光光束でパターン４ａの像をウエハーー６上に投影する。

【００８３】次に本発明の実施例２について説明する。実施例２の装置構成は図１の実施例１と略同じである。実施例２が実施例１と異なる点はレチクル４上のパターンに位相シフト法を適用していることである。

【００８４】図９は本実施例のレチクル４上のパターン４ａの説明図である。同図に示すようにパターン４ａが５本のｙ方向に延びるスリット状の開口４０～４４から成っている点は図１の実施例１と同じであるが、図９のパターンは斜線部分４０，４２，４４に透過する光の位相を部分４１，４３を透過する光に対して１８０度変化させる位相シフターが設けられている点に特徴がある。

【００８５】又、本実施例ではアパーチャー８の形状としては図１０に示すように斜線部分４５の遮光部で囲まれた中心の円形部分４６の開口からの光のみが透過できるものを用いている。

【００８６】本実施例では、パターン４ａとアパーチャー８を用いて実施例１と同様の偏光装置９を組み合わせ、図９中のパターン４ａに対して、照明光の偏光方向がスリットの長手方向に平行な方向（ｙ方向）となるようにしている。これによって位相シフト法を用いて良好なパターンの焼付けを行っている。

【００８７】又、レチクル４上のパターン４ａが図９のように１種類でなく、図６のように相異なる方向に繰り返しが生じている複数種の場合でも、実施例１と同様に同じ向きのパターン毎にレチクルを複数枚用いたりマスキングブレードを用いて分割して焼付けを行うことにより、対処できる。

【００８８】次に本発明の実施例３について説明する。実施例３の装置構成も図１の実施例１と略同じである。

【００８９】本実施例ではレチクル４上のパターン４ａとして、図１１に示すものを用いる。図１１中、４はレチクルであり、座標系を前記各実施例と同じくｘｙ面をレチクル４と平行、ｚ軸をレチクル４に垂直になるように定めておく。図１１中、２１０～２１４はパターンＡのスリット状開口部であり、開口部２１０～２１４は矢印２１５で示すｘ方向に繰り返しパターンを構成してい

る。

【0090】同様に220～224はパターンBのスリット状開口部であり、開口部220～224は矢印225で示すy方向に繰り返しパターンを構成している。パターンA、パターンBの夫々に位相シフト法が適用されている。位相シフト法を適用したパターンA，Bの詳細を図12を用いて説明する。

【0091】図12は図11に示したパターンAについて矢印215に沿った断面を描いたものである。図12中、230は透明なガラス基板であり、斜線部231はクロムより成る遮光部である。遮光部231と開口部210～214により周期パターンAが形成されている。位相シフト法は、開口部を透過する光の位相を隣り合う開口部の間で180度ずつ変化させることにより、結像系の解像度を向上させるものであり、図12中の32～34がそこを透過する光の位相を180度変化させる位相シフターを示している。

【0092】周期パターンBに関しても矢印225に沿った断面図は図12と同様になる。位相シフト法を適用したパターンの結像には、レチクル4に垂直な方向（z方向）から照明を行えば良いので、アパーチャー8としては図13に示すように、周辺の斜線部240が遮光部、中心の241が開口となっているものを用いる。

【0093】本実施例では偏光装置9として図14に示すものを適用する。偏光装置9は、そこに入射する光のうち図14中、両矢印50で示したy方向の偏光光のみを透過させるように構成されている。即ち、本実施例におけるステッパーの照明光は、偏光装置9を透過した後はy軸方向に偏光面を有する直線偏光光となる。

【0094】以上の構成でレチクル4上のパターン4aを照明すると、パターンA，Bと照明光の偏光方向の関係は図15及び図16に示すようになる。即ち、パターンAに対しては、図15に示すように偏光方向60はパターンを構成するスリットの長手方向と平行になり、これは前述の通り解像度が向上する条件を満たす。

【0095】一方パターンBに対しては図16に示すように偏光方向61はパターンを構成するスリットの長手方向に垂直になっており、このままではパターンBに対してはパターンAほどの解像度の改善はできない。

【0096】そこで本実施例ではパターンBに入射する直線偏光光束の偏光面を90度回転させて、パターンBのスリットに平行な方向の直線偏光光束でパターンBを照明できるようにしている。

【0097】図17は図11と同様、パターンA，パターンBを示した、レチクル4の平面図であるが、図17のレチクル4はパターンBの直前に入射する直線偏光光束の偏光面を90度回転させる偏光変換装置70を偏光している点が特徴である。偏光変換装置70としては、例えば1／2波長板を適用できる。1／2波長板を適用した際の偏光面回転の様子を図24を用いて説明する。

【0098】図18中、矢印80の方向に進み両矢印81の方向（y方向）に偏光した直線偏光光束に対して偏光変換装置（ここでは1／2波長板）の光学軸82の方向をx軸と45度の角度をなすように配置すると、偏光変換装置70を透過した後の光束は、矢印83の方向に進み、両矢印84で示すようにx軸方向に偏光した直線偏光光束に変換される。

【0099】偏光変換装置70をパターンBの直前に配置することにより、パターンBと照明光束の偏光方向の関係は図19に示すようになる。即ち、両矢印90が示す偏光の方向がパターンBを構成するスリットと平行な関係になるため、パターンBに対してもパターンAと同様の解像度の向上が実現できることになる。

【0100】偏光変換装置70として旋光性を持った光学物質を適用すれば、直線偏光光束の偏光面の回転の大きさは偏光変換装置70の厚みによって制御することが可能になり、その場合には厚みの制御により直線偏光光束の偏光面の回転角度が90度以外の様な値に設定できるため、様々な方向の繰り返しパターンに対して解像度の向上が可能となる。

【0101】本実施例では照明を行うパターンには位相シフト法が適用されているとして説明を行ったが、斜入射照明法を用いた場合でも適用することができるのは言うまでもない。

【0102】以上の各実施例において偏光装置9をレチクル1の表面又は裏面上に形成する変形例がある。

【0103】図20は本発明の像投影方法を半導体素子の製造用のステッパーに適用したときの実施例4の要部概略図である。図中、図1で示した要素と同一要素には同符番を付している。

【0104】図20において、光源1、オプティカルインテグレーター2、照明レンズ3、レチクル4、投影レンズ5、半導体ウエハー6、ステージ7等はそれぞれ図1のものと同様であるのでここでは省略する。

【0105】実施例4が実施例1～3と異なる点は、偏光装置の設置されている光路中の位置である。本実施例では偏光装置59をレチクル54の直前（照明レンズ3とレチクル54の間）に配置し、レチクル54に入射する光の偏光状態をレチクル54の直前で制御する構成になっている。

【0106】ここで、本実施例のレチクル54上のパターン54aは図21に示すように縦方向（y方向）に延びるスリット60～64より成る繰り返しパターンと横方向（x方向）に延びるスリット65～69より成る繰り返しパターンとからなっている。このように、縦横方向のパターンに対して斜入射照明で解像度を向上させるには、アパーチャー8の開口を図22のようにすれば良い。

【0107】図22中の斜線部70は遮光部で4隅に設けた円形開口部71～74が光透過部となっており、こ

の開口７１～７４からの光をレチクル４に斜め入射させる。

【０１０８】本実施例ではこのような斜入射照明法に対して、パターン５４ａに入射する光の偏光方向がスリットの長手方向に対して常に平行になるように、偏光装置５９を配置したものである。

【０１０９】図２１中の５９ａ，５９ｂは入射した光のうちある一つの方向に偏光した直線偏光光のみを透過させる偏光部材であり、偏光部材５９ａは入射した光のうちスリット６０～６４の長手方向に平行な方向（ｙ方向）、に偏光した偏光光のみを透過するように設置されている。

【０１１０】一方、偏光部材５９ｂはスリット６５～６９の長手方向に平行な方向（ｘ方向）に偏光した偏光光のみを透過させるように配置されている。偏光装置５９としては、薄膜状の偏光板をその偏光軸方向を対応するパターンに合わせて決めてレチクル５４上に貼りつけたもの等が適用可能である。

【０１１１】本実施例では、レチクル５４上のパターン５４ａとして縦横２方向に延びるスリットを持つものについて説明したが、それ以外の方向に延びるスリットを持つパターンに対しても同様に適用可能である。

【０１１２】尚、本実施例において偏光装置９をレチクル５４の直後（レチクル５４と投影レンズ５５との間）に配置しても良い。

【０１１３】このとき偏光装置９はレチクル５４上に種々の方向に延びるスリットがあってもスリットから回折された光のうち、それぞれの方向のスリット毎に独立にスリットの長手方向に偏光した偏光光を選択できるようにし、そして、この偏光光で結像するようにしている。

【０１１４】次に本実施例の実施例５について説明する。実施例５の装置構成は図１の実施例１と略同じである。実施例５が実施例４と異なるのはレチクル４上のパターンに位相シフト法を適用していることである。

【０１１５】図２３は本実施例のレチクル５４面上のパターン５４ａの説明図である。同図に示すレチクル５４上のパターンは縦方向（ｙ方向）に延びるスリット８０～８４、及び横方向（ｘ方向）に延びるスリット８５～８９から構成されている点では図２１のパターンと同様であるが、本実施例では図中のスリットで斜線が施されている部分８０，８２，８４，８５，８７，８９に透過する光の位相を部分８１，８３，８６，８８を透過する光に対して１８０度変化させる位相シフト部材を設けている点が異なっている。

【０１１６】５９ａ，５９ｂは偏光部材であり、レチクル５４に円もしくは楕円に偏光した光もしくは非偏光光が入射したときに、その光のうちスリットの長手方向に偏光した偏光光のみをスリットに入射させている。又、アパーチャー８としては実施例２の場合と同様図１３に示したものを用いている。

【０１１７】本実施例では以上のような構成によって、位相シフト法によって解像度の向上を図り、かつレチクル５４上に縦横方向のパターンがある場合でも、各パターンに適した偏光光で半導体ウエハー６上に結像している。

【０１１８】ここではレチクル５４上のパターンとして縦横２方向に延びるスリットを持つもので説明したが、それ以外の方向に延びるスリットを持つパターンに対しても同様に適用可能である。

【０１１９】ここではレチクル上のパターンが５本のライン＆スペースで形成されている場合を例にとり示したが、５本以外のライン＆スペースパターンについても同様に適用可能である。又、ライン＆スペースの幅の比は１対１に限られるものではなく、更にパターンの周期性がある程度不規則になった場合でも同様に適用可能である。

【０１２０】又、ランプと偏光装置を用いず、直線偏光光を発するレーザーを露光用の光源としても良い。又偏光装置を用いるときやレーザーを用いるときに１／２波長板を光路に入れ、これを回転させて所望の偏光光を作るようにしても良い。

【０１２１】次に上記説明した露光装置を利用したデバイス製造方法の実施例を説明する。図２４は半導体素子（ＩＣやＬＳＩ等の半導体チップ、あるいは液晶パネルやＣＣＤ等）の製造のフローを示す。

【０１２２】ステップ１（回路設計）では半導体素子の回路設計を行なう。ステップ２（マスク製作）では設計した回路パターンを形成したマスクを製作する。

【０１２３】一方、ステップ３（ウエハー製造）ではシリコン等の材料を用いてウエハーを製造する。ステップ４（ウエハープロセス）は前工程と呼ばれ、上記用意したマスクとウエハーを用いてリソグラフィ技術によってウエハー上に実施例の回路を形成する。

【０１２４】次のステップ５（組み立て）は後工程と呼ばれ、ステップ４によって作成されたウエハーを用いて半導体チップ化する工程であり、アッセンブリ工程（ダイシング、ボンディング）、パッケージング工程（チップ封入）等の工程を含む。ステップ６（検査）ではステップ５で作製された半導体素子の動作確認テスト、耐久性テスト等の検査を行なう。こうした工程を経て半導体素子が完成し、これが出荷（ステップ７）される。

【０１２５】図２５は上記ウエハープロセスの詳細なフローを示す。

【０１２６】ステップ１１（酸化）ではウエハーの表面を酸化させる。ステップ１２（ＣＶＤ）ではウエハー表面に絶縁膜を形成する。ステップ１３（電極形成）ではウエハー上に電極を蒸着によって形成する。ステップ１４（イオン打込）ではウエハーにイオンを打ち込む。ステップ１５（レジスト処理）ではウエハーに感光剤を塗布する。ステップ１６（露光）では上記説明した露光装

置によってマスクの回路パターンをウエハーに焼付け露光する。ステップ１７（現像）では露光したウエハーを現像する。ステップ１８（エッチング）では現像したレジスト像以外の部分を削り取る。ステップ１９（レジスト剥離）ではエッチングが済んで不要となったレジストを取り除く。これらのステップを繰り返し行うことによって、ウエハー上に多重に回路パターンが形成される。

【０１２７】本実施例の製造方法を用いれば、従来は製造が難しかった高集積度の半導体素子を製造することができる。

【０１２８】

【発明の効果】本発明によれば以上のように各要素を設定することにより、微細パターンを結像するのに好適な、改良された結像方法及び該方法を用いる露光装置及び該方法を用いてデバイスを製造する方法を達成することができる。

【０１２９】この他本発明によれば以上のように周期性のあるパターンを投影光学系で所定面上に投影する際、投影に用いる光束の偏光状態をパターンの周期方向に対応させて適切に設定することにより、高い解像力を維持しつつ高コントラストで投影することができる半導体素子の製造に好適な像投影方法及び露光装置、更には製造方法を達成することができる。

【図面の簡単な説明】

【図１】　本発明の像投影方法をステッパーに適用したときの実施例１の要部概略図

【図２】　図１のレチクルの説明図

【図３】　図１のレチクルに対する照明光の様子を示す説明図

【図４】　図１のアパーチャーの説明図

【図５】　図１の偏光装置の説明図

【図６】　図１のレチクルの他の実施例の説明図

【図７】　図６の一部分の説明図

【図８】　図６の一部分の説明図

【図９】　本発明の実施例２にかかるレチクルの説明図

【図１０】　本発明の実施例２にかかるアパーチャーの説明図

【図１１】　レチクル上のパターンを表す図

【図１２】　図１１のレチクル上のパターンの断面を表す図

【図１３】　本発明の実施例３に係るアパーチャーを表す図

【図１４】　本発明の実施例３に係る偏光装置を表す図

【図１５】　図１１のパターンと照明光の偏光の関係を表す図

【図１６】　図１１のパターンと照明光の偏光の関係を表す図

【図１７】　本発明の実施例３に係るレクチル上のパターンを表す図

【図１８】　本発明の実施例３に係る偏光変換装置の働きを表す図

【図１９】　図１７のパターンと照明光の偏光の関係を表す図

【図２０】　本発明の像投影方法をステッパーに適用したときの実施例４の要部概略図

【図２１】　図１１の一部分の説明図

【図２２】　図１１の一部分の説明図

【図２３】　本発明の実施例５に係るレチクルの説明図

【図２４】　本発明に係る半導体素子の製造方法のフローチャート図

【図２５】　本発明に係る半導体素子の製造方法におけるウエハープロセスのフローチャート図

【図２６】　瞳上の振幅分布を表す説明図

【図２７】　光線の角度による偏光方向の違いを説明するための説明図

【図２８】　スリットに平行な方向に偏光した光を用いたときの像面上の強度分布を表す説明図

【図２９】　スリットに垂直な方向に偏光した光を用いたときの像面上の強度分布を表す説明図

【図３０】　スリットに平行な方向に偏光した光を用いたときの位相シフト法、斜入射照明による像面上の強度分布の説明図

【図３１】　スリットに垂直な方向に偏光した光を用いたときの位相シフト法、斜入射照明による像面上の強度分布の説明図

【図３２】　繰り返しパターンの振幅透過率を表す説明図

【図３３】　瞳上の振幅分布を表す説明図

【図３４】　像面上の強度分布を表す説明図

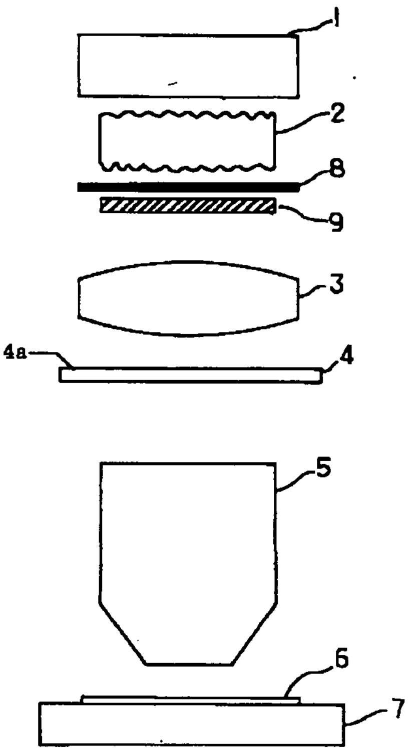
【図３５】　位相シフト法を用いた場合の瞳上の振幅分布を表す説明図

【図３６】　斜入射照明を用いた場合の瞳上の振幅分布を表す説明図

【符号の説明】

1　光源
2　オプティカルインテグレーター
3　照明レンズ
4　レチクル
5　投影レンズ
6　半導体ウエハー
7　ステージ
8　アパーチャー
9　偏光装置

【図１】



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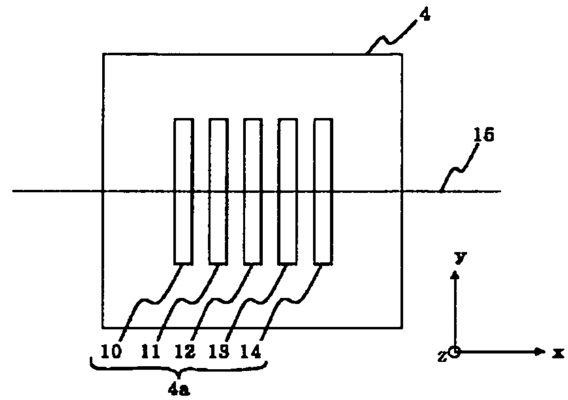

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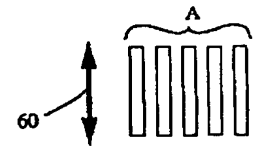

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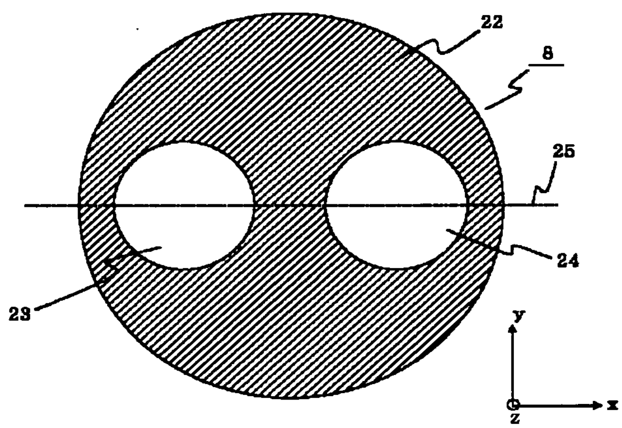

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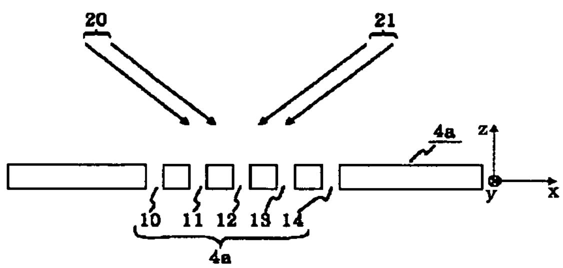

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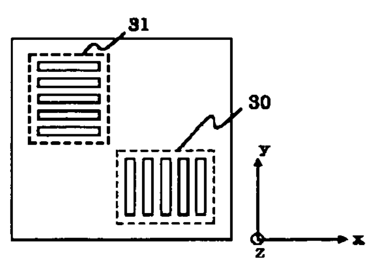

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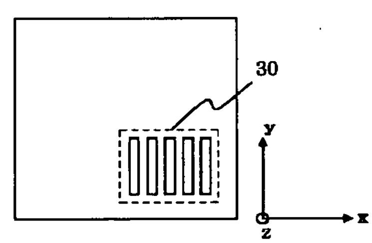

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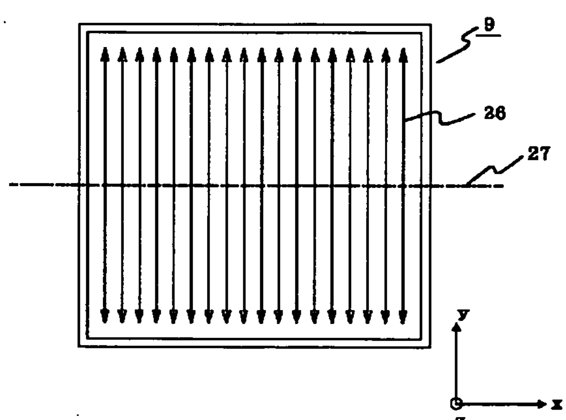

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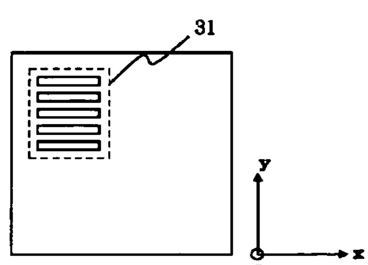
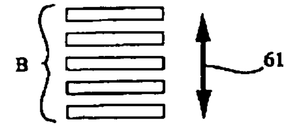


【図１６】



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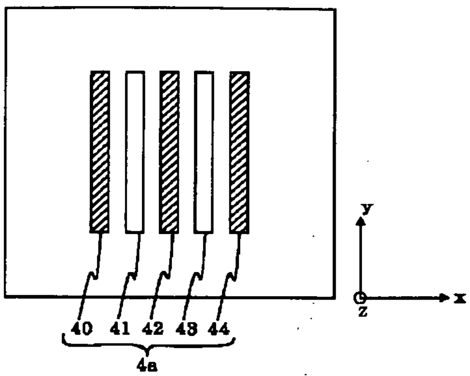

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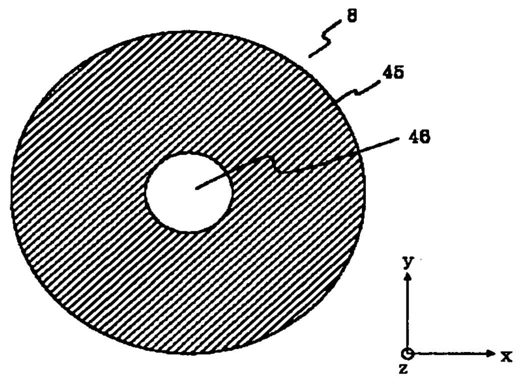

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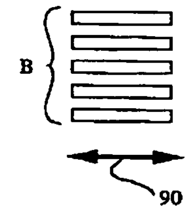

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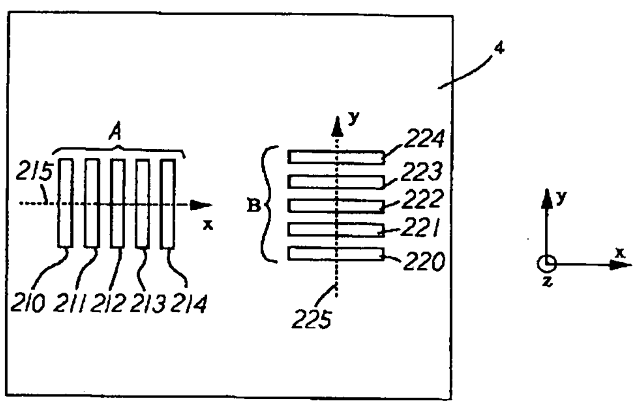

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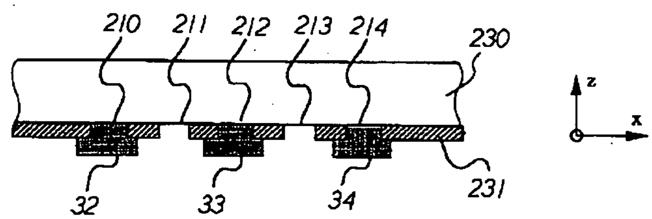

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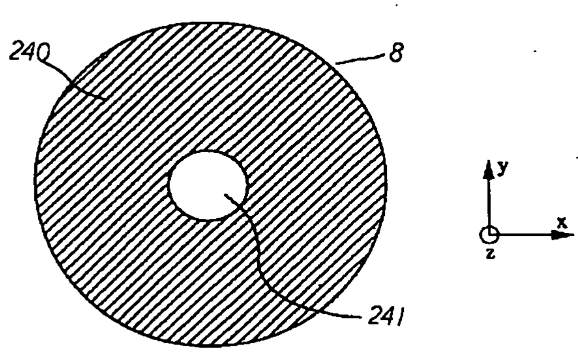

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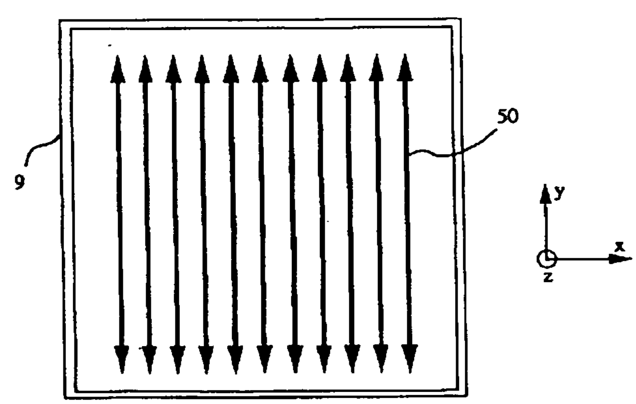
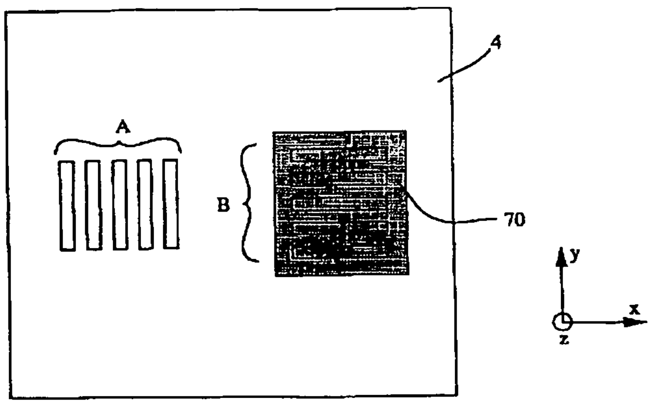


【図１７】



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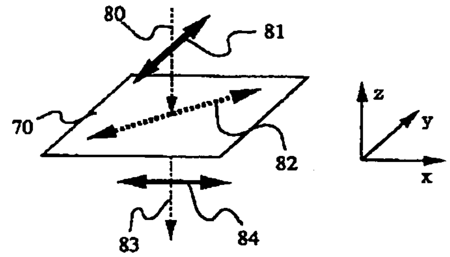

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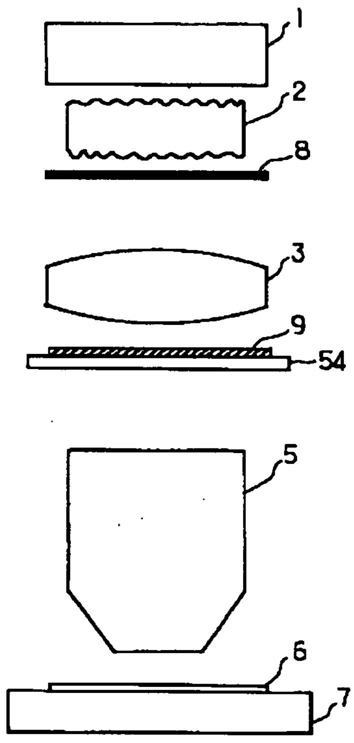
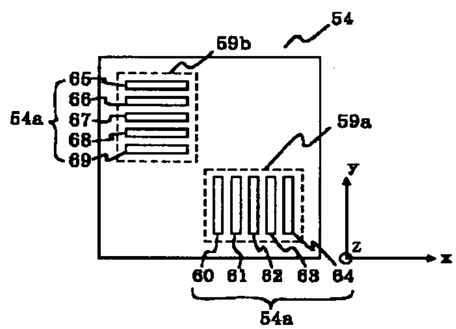


【図２１】



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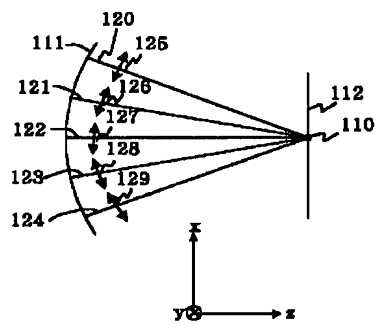

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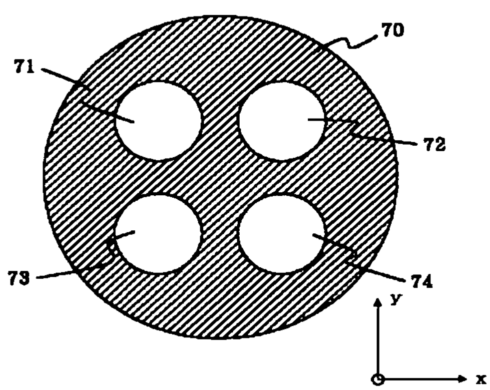

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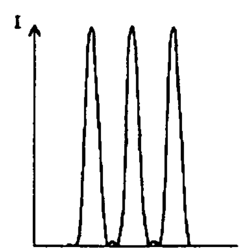

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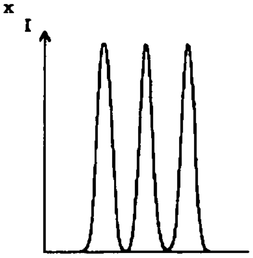

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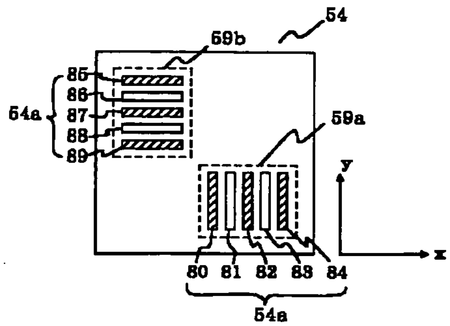

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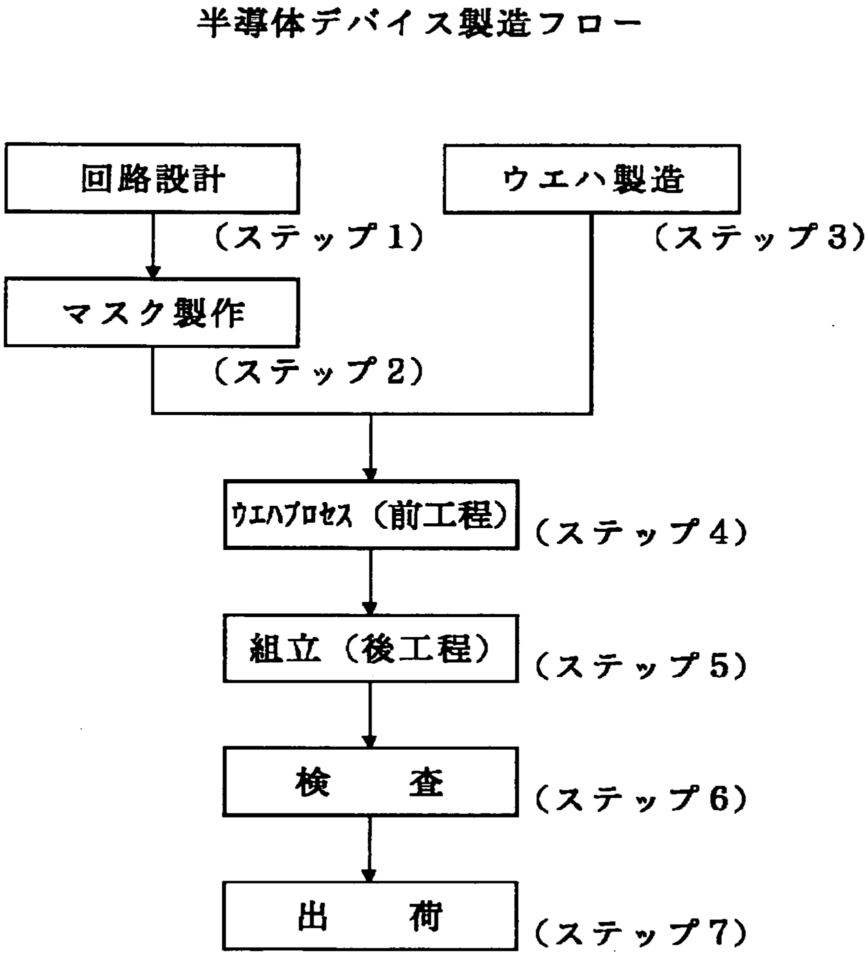

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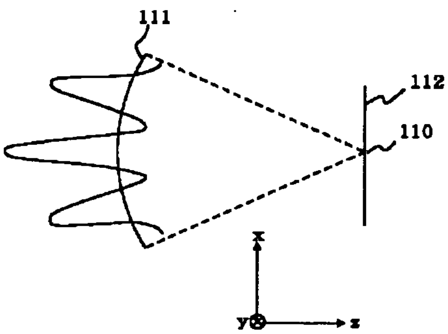

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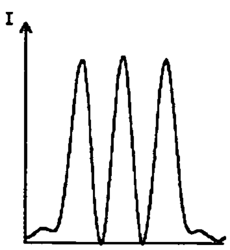
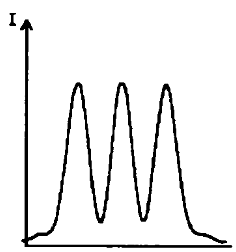


【図３１】



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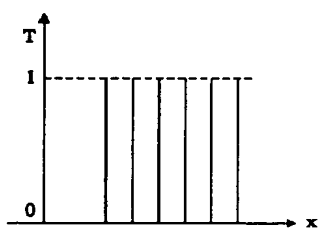

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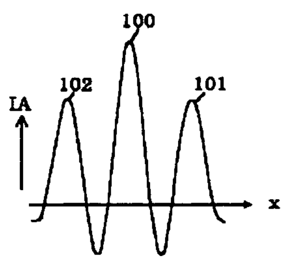

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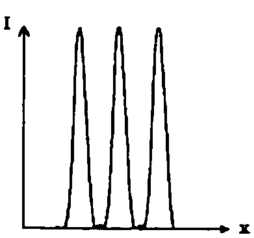

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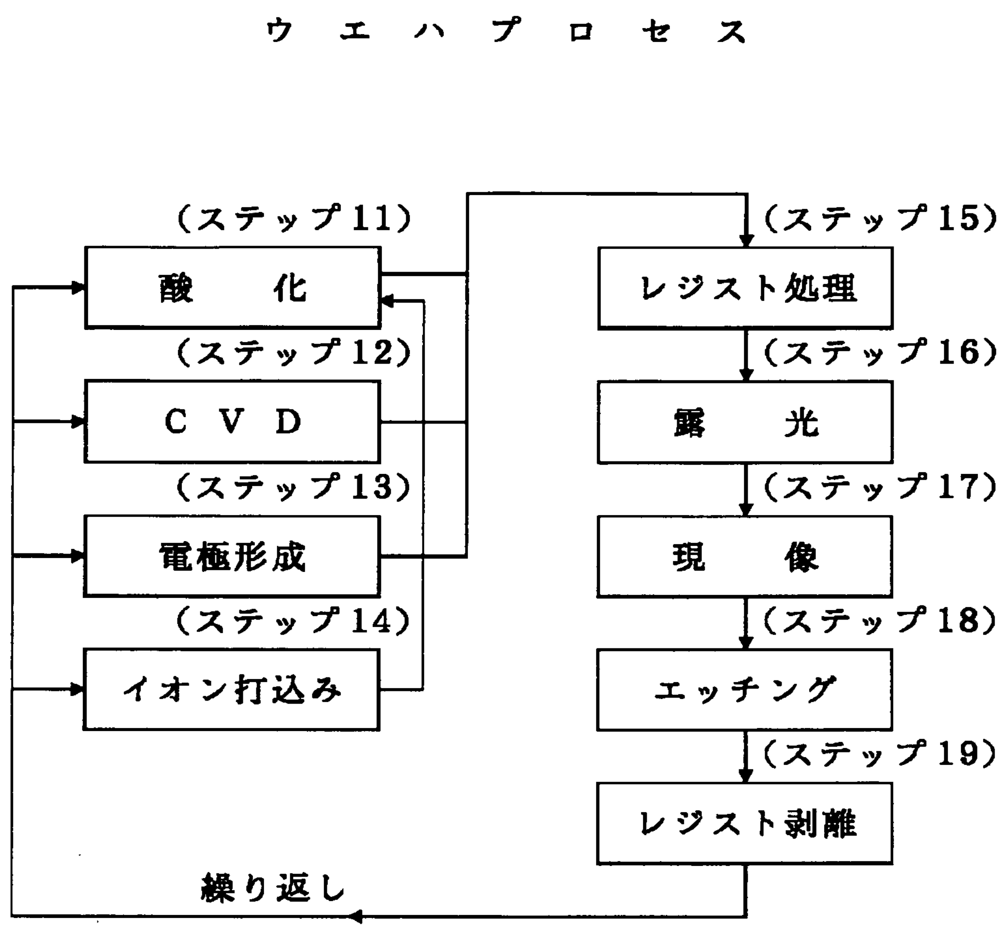

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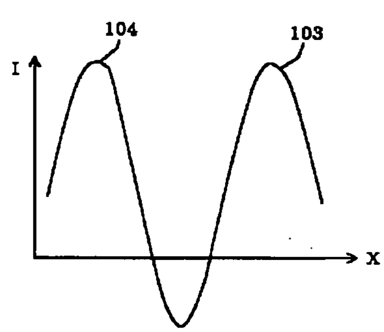

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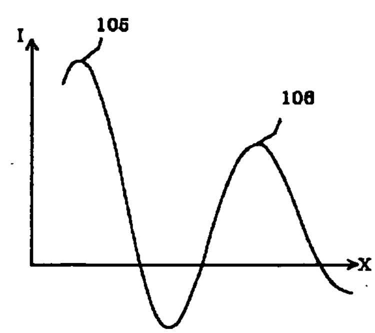

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G11B　5/31	M	8947−5D		